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GEORGE REID
Editor

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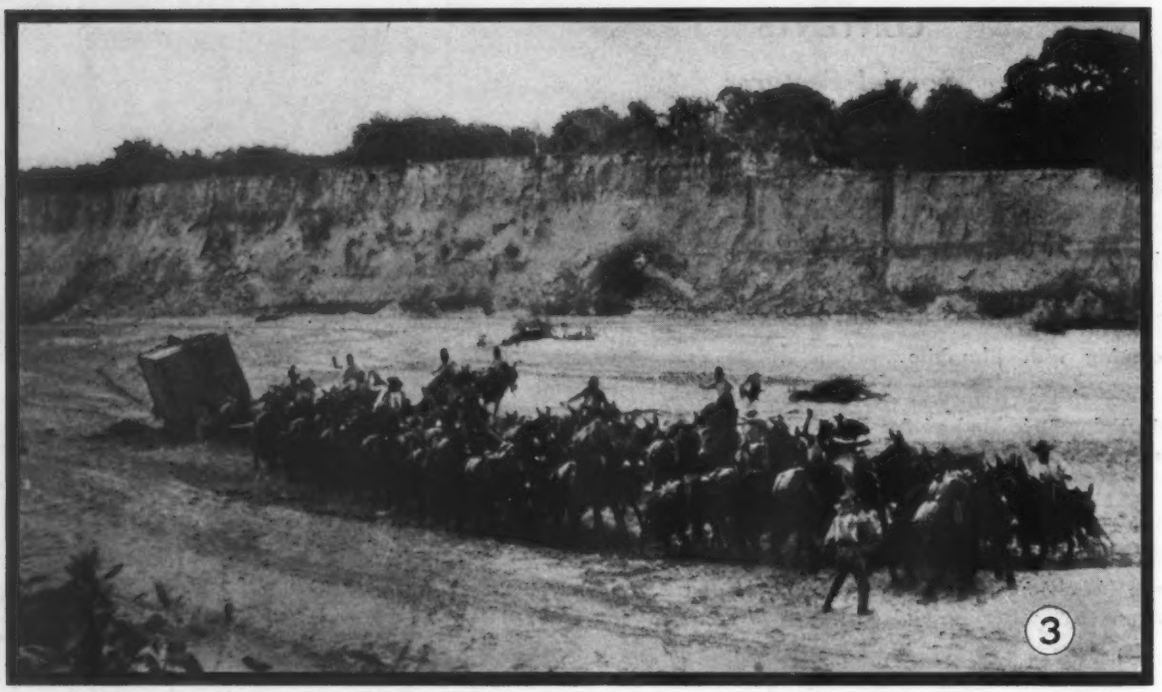

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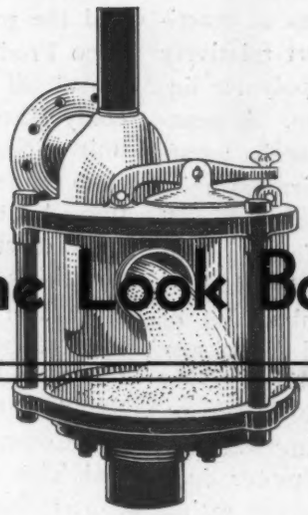


The Look Box

Polymerization . . .

COMMERCIAL polymerization practices, toward which the industry is drifting more rapidly than was thought possible just a few months back, is an important achievement of the chemical engineer. In fact, it is looked upon by many as the most important chemical engineering achievement of the present decade. A hurried study of its possibilities brings to light the fact that the "poly" plant in all likelihood will mean as much to the industry technically and economically as did the advent of liquid-phase cracking. Polymerization is the tool needed by the industry for the preparation of motor fuels of higher octane rating which will be demanded in the near future. Its extensive use as a tool for production of both more gasoline and better gasoline is certain. Several of these plants, some large and some of semi-commercial or pilot type, are in operation and others are proposed. One large installation will soon go into construction on the Texas Gulf Coast. Foreign interest is reported to be more important than was expected. The present licensors of the three available processes are very busy with estimating and with preparations for construction of plants.

The gases produced by cracking, the increasing volume and low value, have spurred on certain research workers for the past several years. Close contact with some engaged in this research and knowledge of the rapidity of the development has contributed to certain prophetic editorial treatments in these columns during recent years. It was once editorially surmised that at some future date motor fuel specifications might be written on the basis of designating quantities by percentage of saturates and unsaturates permissible in a given motor fuel. The possibilities of polymerization as a tool for preparation of motor fuels predominantly of unsaturates now are obvious, although it is granted that widespread production of such motor fuels remains some years in the future. The process, however, may well be an important contributor toward production of motor fuels of better uniformity chemically. Chemical non-uniformity is the quality lacking in present day motor fuels that causes

variation in performance characteristics, all other factors being equal.

Of the three polymerization processes now being offered the industry, two are of the catalytic type, which polymerize olefinic cracking plant gases to liquids boiling in the gasoline range with unusually high blending values. Another process converts paraffin hydrocarbons to olefins and then polymerizes these into liquids of high octane value and blending value. The newer processes will charge liquids or gases of practically any type and ultimately convert relatively large percentages of the charge to polymer liquids for use as a blending medium. A separation of light distillates predominantly paraffinic for special treatment in polymerization units is a logical step and such separation may well come about after the cracking and reforming unit has done all it can with material usually charged to its furnaces. A process or combination of processes is in the offing which will digest any material given it and produce motor fuels markedly predominating in unsaturates or polymers which will come close to answering the approaching demand for 100 octane motor fuel. Aviation, with its need for 100 octane rating fuels, received its needs but recently. The automobile does not need it yet, but the time is coming. There are so many possible variations of application of polymerization to motor fuel production that its influence upon the industry is extremely difficult of appraisal.

During the year the principle published work dealing with the technology of polymerization has been presented before the spring and fall meetings of the American Chemical Society. The symposium presented at the spring meeting has been published in the August and September issues of the society's "Industrial and Engineering Chemistry," and the work presented in the fall meeting will be published later this winter. At the semi-annual meeting of the American Petroleum Institute, Universal Oil Products Company presented its process under the title "Polymer Gasoline From Cracked Gases," which was published in the June issue of The Refiner, Vol. 14, No. 6, page 249. Elsewhere in this issue is a non-technical discussion of "Thermal Polymerization of Gaseous Hydrocarbons," released late in September by The Polymerization Process Corporation (now, for the sake of brevity, becoming rather widely known as "Polyco"). At the annual meeting of the American Petroleum Institute next month in Los Angeles, a number of papers dealing with all three of these processes now being licensed are to be presented. These will be published in The Refiner, issue of November, 1935. Thus both the fundamental information and the technical data relative to this important development are being widely disseminated.

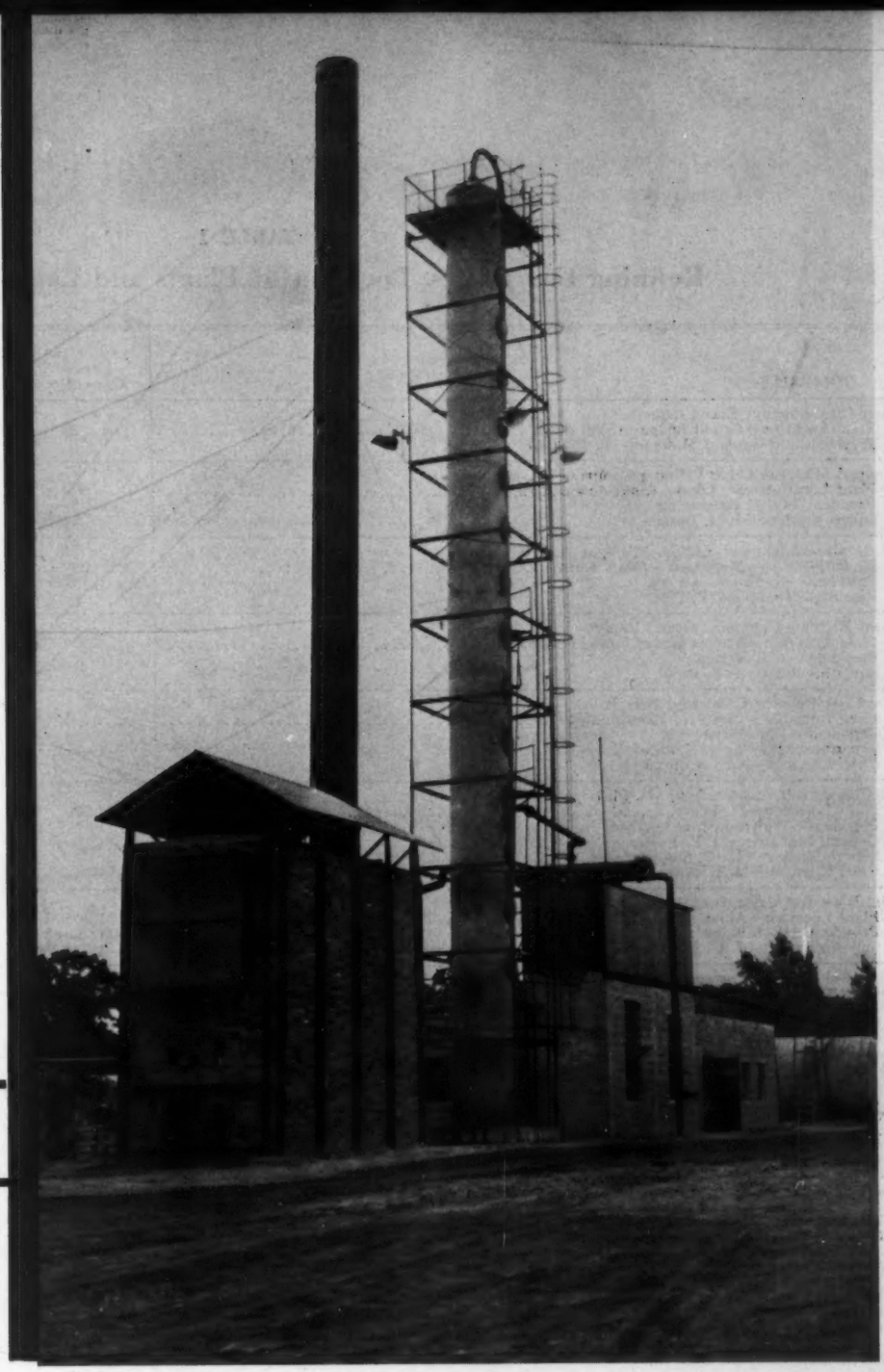
The work of The Pure Oil Company in development of its Gyro polymerization process is rather widely known. This company has been using its own process with satisfactory results and the process now is being licensed through Alco Products, Inc. Likewise the work of Universal Oil Products Company in this field, especially through the operation of the commercial unit at Shell Petroleum Corporation's East Chicago refinery, has attracted a great deal of attention. A large unit of this process is scheduled for early erection at Pan American Petroleum Corporation's Texas City refinery.

In The Polymerization Process Corporation are grouped the patents and processes of Phillips Petrolem Company, a pioneer in the field, Standard Oil Company (New Jersey), Standard Oil Company (Indiana), The Texas Company and The M. W. Kellogg Company, the latter concern being the licensing agent.

With this group offering and owning processes it is logical to assume that the companies involved will progress rapidly in the establishment of commercial units at their refineries. This work involves Shell Oil Company of California and Standard Oil Company of California, owners of Universal Oil Products Company; continued development on the part of The Pure Oil Company, developers of the Gyro process; and utilization of the "Polyco" process by those involved in that corporation. These include Standard Oil Company (Indiana) with its subsidiaries, Pan American Refining Corporation, Utah Oil Refining Company and Stanolind Oil & Gas Company, also The Texas Corporation and The Texas Company of California; Phillips Petroleum Company with one unit operating at Borger, Texas, and with additional refineries at Okmulgee, Oklahoma, and Kansas City, Missouri; and in Standard Oil Company of New Jersey group is Standard Oil Company of Louisiana, Humble Oil & Refining Company and Colonial Beacon Oil Company. The operating refineries of all these companies are equipped with cracking processes.

With successful commercial application of polymerization work definitely established, and with recovery running usually from three to six gallons per

(*Continued on page 41a*)



McClanahan Refineries, Inc., plant at St. Louis, Michigan.

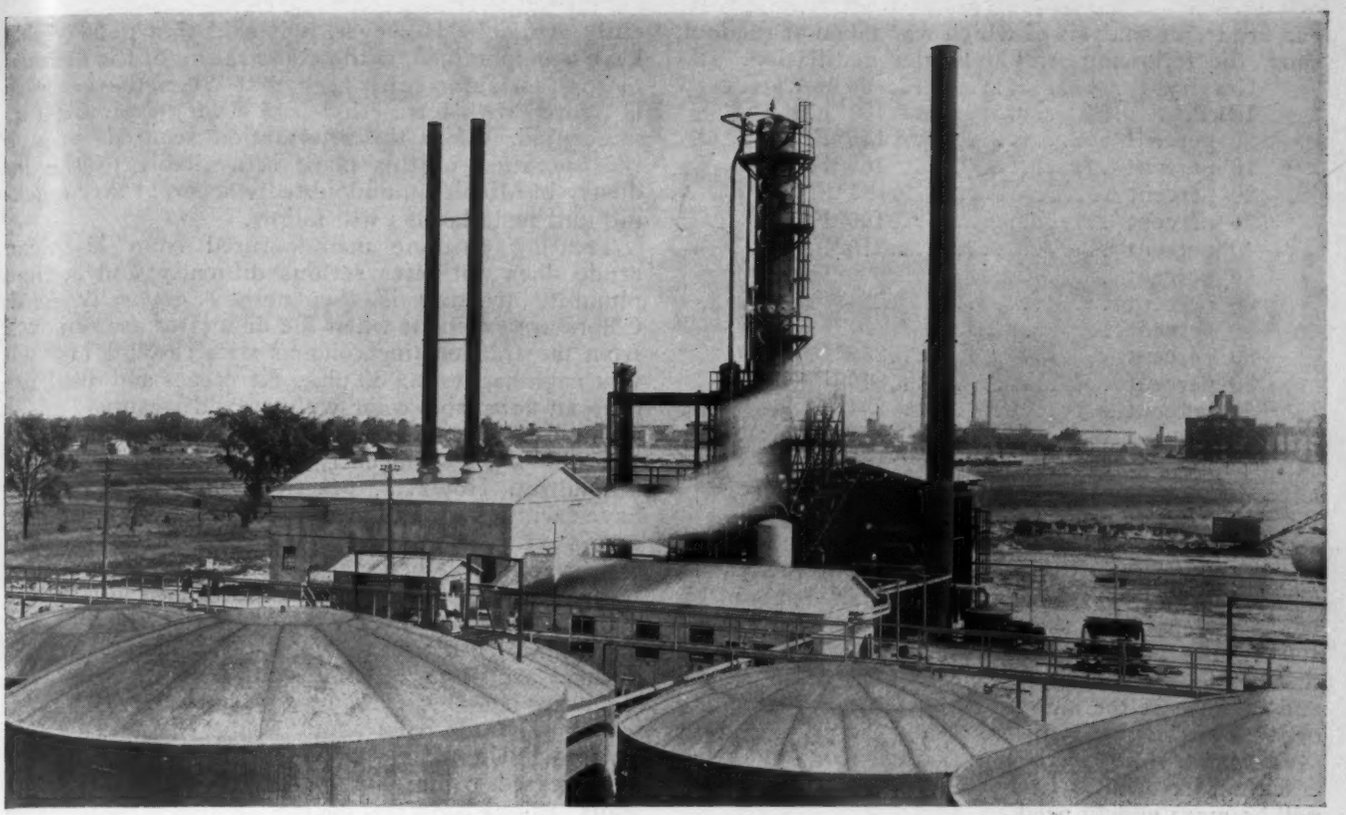
Cracking *to Aid* Michigan Refineries

SEVENTEEN companies engaged in refining in Michigan, with 18 refineries, have a total crude charging capacity of about 40,000 barrels daily. Most of these refineries are simply skimming plants; most of them having facilities included in the design for the manufacture of special naphthas, chiefly rubber solvents, varnish and painters naphthas and Stoddards naphtha. Only two cracking plants have been erected, one of these being the White Star Refining Company installation at Detroit, now several years old (REFINER, June 1930, page 81), and the recently completed Dubbs installation at Naph-Sol Refining Company's Muskegon refinery. Several additional skimming plants are contemplated in the near future, and

TABLE 1

Refining Companies, Location of Plants and Capacity in Michigan

COMPANY	Crude Capacity	Type	CRACKING Capacity	CRACKING Type
Bair Oil Company, Grand Ledge Plant Location—Grand Ledge (Shut down) President and General Manager—F. M. Bair	100	skim		
Central Michigan Oil & Refining Company Plant Location—St. Louis (Shut down) President—O. A. Bucanning Superintendent—I. H. Beattie	500	skim		
H. H. Cross Company, 122 So. Michigan Ave., Chicago Plant Location—Muskegon (Shut down) President—H. H. Cross Vice President—Geo. P. Fox	500	skim		
Kent Refining Company, Grand Rapids Plant Location—5 miles east of Grand Rapids President—J. J. Kerins Superintendent—J. B. Ryan	500	skim		
Keystone Refining Company, Detroit Plant Location—12080 Northampton St. President—Wm. Fisher Superintendent—Leon Komisaruk Chief Chemist—Amos Comay	1,400	skim		
McClanahan Refineries, Inc., Mt. Pleasant Plant Location—St. Louis President—Walter L. McClanahan General Manager—D. E. Foster Superintendent—M. C. Sumpter Chief Chemist—M. C. Sumpter	1,500	skim		
Mid-West Refineries, Inc., Alma Plant Location—Alma President—B. J. Skinner Superintendent—J. G. Marshall	1,200 1,500 (bldg.)	skim skim		
Naph-Sol Refining Company, Muskegon Plant Location—Muskegon President—Walter F. Anerson Superintendent—H. B. Burrell Chief Chemist—W. C. Fisher	2,500	skim	500	Dubbs
Old Dutch Refining Company, Muskegon Plant Location—East of Muskegon President—John Borden Superintendent—F. H. McCormick Assistant—C. Mitchel Chief Chemist—Dr. Geo. Van Epps Chemist—Del Camp	3,000	skim		
Peerless Refining Company, Grand Rapids Plant Location—Grand Rapids (Shut down) Plant Location—Saginaw (Shut down) Owners—Taggart Brothers	500 500	skim skim		
Pentagon Refining Company, Plymouth Plant Location—Plymouth (Building) President—Herbert J. Conn Construction Engineer—E. G. Guy Construction Superintendent—R. J. Lee	1,500	skim		
Pure Oil Company, Chicago, Ill. Plant Location—Midland General Superintendent—R. C. Osterstrom Superintendent—K. B. May Assistant—R. H. Kidder Resident Chemist—C. L. Harlinger	3,500	skim		
Roosevelt Oil Company, Mt. Pleasant Plant Location—Mt. Pleasant President—C. L. Maguire Superintendent—E. R. Hively Assistant—Ralph Norris Chief Chemist—W. B. Howard	5,000	skim		
Standard Oil Company (Indiana), Chicago Plant Location—Zilwaukee (Shut down)	1,800	skim		
Superior Oil Company, Elsie Plant Location—Elsie President—H. J. Smith Superintendent—Robt. Guy	750	skim		
Sweet Oil Refining Company, Wyman Plant Location—Wyman President—H. H. Rice Vice President and General Manager—Max Pray	750	skim		
White Star Refining Company, Detroit (Socony-Vacuum Oil Company Subsidiary) Plant Location—Trenton President—H. A. Coffin Executive Assistant—H. M. Sullivan Superintendent—S. G. Keller Chief Chemist—E. H. Potthoff Chief Engineer—C. R. Miller	12,000	skim	6,000	4—Dubbs 1—White Star



The Pure Oil Company's Midland, Michigan plant.

two are scheduled for immediate construction. Further, several companies are giving thought to construction of cracking units and reforming units, or combinations of cracking and reforming units. Polymerization processes will also prove of advantage in this area.

The average refining conditions in Michigan are peculiar to that district in that the crude produced from the majority of the fields refines easily into straight-run products of good quality except for octane rating, and the lighter fractions are readily adaptable to fractionation into solvent naphthas of excellent grade. The anti-knock value of the gasoline fraction is much lower than any other major producing and refining district in the United States. Such conditions brought about the investigation of adoption of the cracking process for cracking gas oil and topped crude, as well as reforming the straight-run products. Fair yields are reported when skimming, cracking, and reforming is employed, but, it is said, where the desirable octane rating is secured, the operation is accompanied by large fixed gas production. Information is not currently available as to what may be accomplished with the various polymerization processes when used to treat the gases produced by the cracking units operating on Michigan stocks. It is apparent, however, that cracking, naphtha reforming, and perhaps polymerization, are the tools necessary to production of motor fuel with good anti-knock characteristics. Lead susceptibility of distillates from Michigan crude is generally poor. Thus it is apparent that the concerns refining the majority of the crudes produced in Michigan must resort to the use of all of the currently available processes designed for producing both satisfactory yields and octane rating, if this crude is to be processed for motor fuel. Such operation is costly of installation, therefore many of the refineries in the state have been satisfied with either the production of third-grade motor fuel selling at one cent per gallon less, in tank car lots, or they have gone into the production of solvent naphthas for which products good prices have been received.

It is said by some refiners that the present capacity of plants in Michigan, built chiefly for production of gasoline with low octane rating and special solvent naphthas, is ample to supply existing markets. If this be true then the logical course for concerns operating in the area is that of installation of processes capable of producing motor fuel of high octane rating, and that is the trend at present. Those concerns going into the cracking and reforming field will produce gasoline of higher quality and receive, accordingly, higher prices for the product. As more concerns engage in the production of motor fuel rather than solvent naphthas, still other plants are established for preparation of low-grade gasoline and high-grade solvent naphthas, and the Michigan refining district continues to grow in importance in total capacity and number of refineries.

Yields from refinery operation processing Michigan crude are shown below. The data is from a refinery which is fairly representative of the district.

	Percent
Rubber Solvent	17
VM&P naphtha	7
Stoddards solvent	10
Kerosene	10
Distillate	11
UGI gas oil	13
Fuel oil	30
Gas and loss	2
	100

Car loadings of straight run gasoline from Michi-

gan crude, an analysis of which was taken at random, show the following ASTM-Engler distillation.

Gravity	68.6°A.P.I.
I.B.P.	104°F.
5 percent	146°F.
10 percent	162°F.
20 percent	182°F.
30 percent	196°F.
40 percent	210°F.
50 percent	222°F.
60 percent	234°F.
70 percent	246°F.
80 percent	258°F.
90 percent	279°F.
94 percent	294°F.
Dry	298°F.
End Point	325°F.
Recovery	94 percent
Residue	.5 percent
Distillation loss	5.5 percent

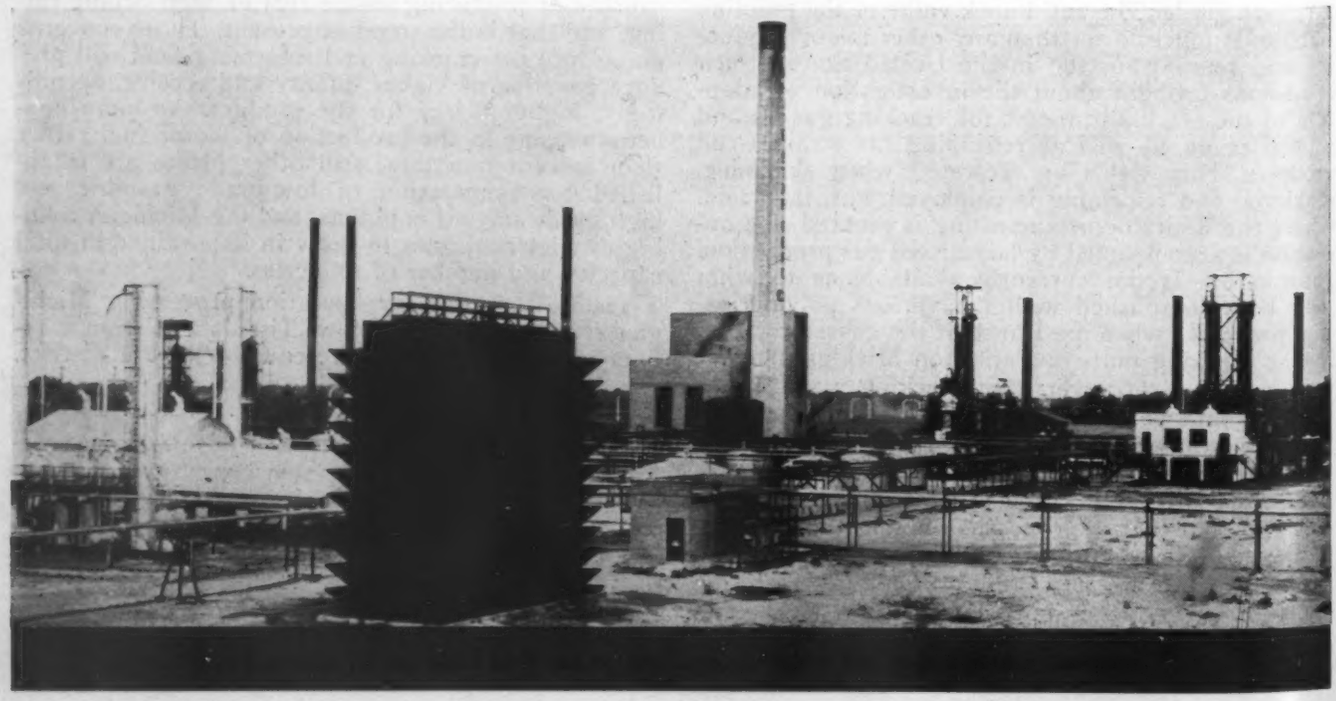
The octane rating of the above motor fuel, when untreated with benzol or other materials, is about 25. If the end point of the gasoline is raised to around 400°F., the octane rating is appreciably lower; in some instances falling to as low as 15. For this reason and because of the amount of gasoline available and because of the quality of the product in every respect save octane rating, it is only logical to assume that cracking, reforming and polymerization processes will be more widely used.

A large portion of the Michigan crude is not refined within the state but is shipped to the plants of large companies in nearby refining districts. At Toledo, Ohio, for example, it is refined by Pure Oil Company, Standard Oil Company of Ohio, Sun Oil Company, Gulf Refining Company, and Wayco Refining Company. White Star Refining Company (White Star division of Socony-Vacuum Oil Company), at Detroit, has in the past operated on Michigan crude, but is not doing so at present. The Dubbs cracking plant erected this year by Naph-Sol Refining Company, Muskegon, is operating on Michigan topped crude, but information as to results, both as to octane rating secured and yields from the plant, is not presently available. However, it is said that good yields have been obtained, with octane rating of the finished motor fuel sufficiently high that when the gasoline is treated with tetra ethyl lead a very desirable fuel is secured. When the information secured through the operation of this plant is available to the industry in Michigan, undoubtedly several other cracking unit installations will follow.

Treating gasoline manufactured from Michigan crude does not offer serious difficulty and sodium plumbite treating is the method generally used. Colors are excellent when the distillates are removed from the fractionating columns with gasoline and solvent naphthas testing 30 plus. Kerosenes and distillates have an acceptable color without acid treating.

Corrosion has not been encountered in straight distillation work sufficiently severe to cause serious difficulties. However, practically all of the plants have facilities for the introduction of anhydrous ammonia as a means of preventing corrosion to condenser coils, this being the only point in the system seriously affected. Ammonia is purchased in standard cylinders, metered to the vapor lines at a point varying from the outlet of the columns to a point near the primary exchanger or condensing section.

During 1934 Michigan produced over 10,000,000 barrels of crude from about 1100 wells, and its production during this year should be greater because of increased drilling activity and exploitation of new pools. About 5,000,000 barrels of this production in 1934 was refined within the state, and the refining experience during this year will be in about the same ratio. During 1932 Pure Oil Company entered the state with a 3500-barrel plant at Midland, (REFINER, September, 1932, page 482, "Automatic Control Features New Michigan Refinery"), but since that time none of the major companies have established refineries in the area, chiefly because of the proximity of large established refineries being operated by the larger companies at Toledo and Chicago. These nearby refining centers offer a convenient market for Michigan production which is above that quantity required by the 18 refineries erected in the last few years within the state.



Special Products

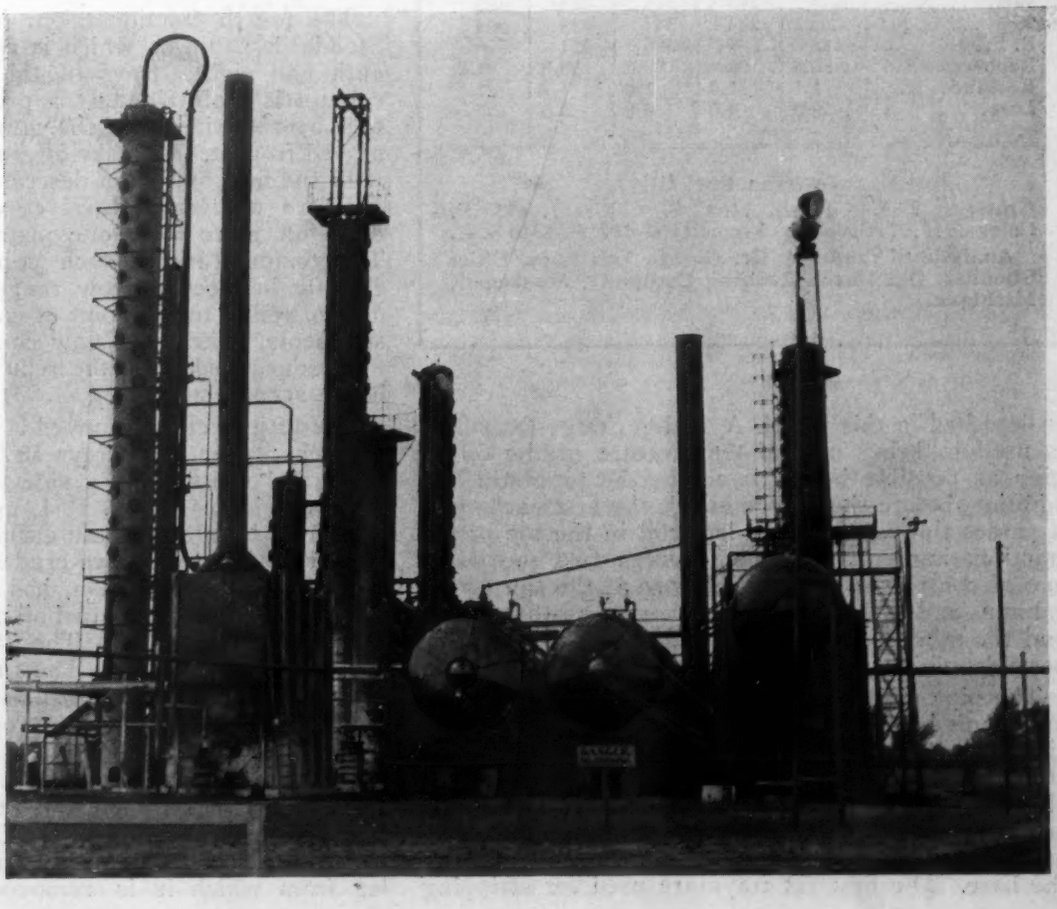
Continuously on Improved Still

J. C. ALBRIGHT

UNTIL March, 1934, Old Dutch Refining Company, Muskegon, Michigan, was operating its refinery with a pipe still and three shell stills. Mount Pleasant crude was pumped through the pipe still at the rate of about 2000 barrels daily. The entire distillate cut was thrown together so that special naphthas could be separated by redistillation in the shell stills.

This method of operation was not satisfactory for two reasons: first because of the necessity of rerunning the distillate for the special fractions, and second because of the restricted throughput of crude pumped to the stills. Consequently, plans were made so that the pipe still could be operated as one unit and the shell stills in the same manner, both then being charged with fresh crude. Company engineers in collaboration with Leader Industries, Inc., designed two special towers for making special naphthas, both of which were connected to the pipe still transfer line; the taller tower taking the job of flashing, while the second and smaller tower was to redistill or side-strip the separate fractions. The larger tower is 60 inches in diameter by 88 feet high, fabricated locally and of welded construction. Seams were butt-welded, inside and outside, and the tower was provided with a bolted man-hole cover at each bubble plate. Thirty bubble trays were placed in the column and the plates were equipped as draw-off pans as well as fractionating plates.

The oil is charged through exchangers on the heavier fractions and travels to the dehydrator where a closed coil brings the temperature sufficiently high that most of the salt and foreign matter in the crude



Old Dutch Refinery at Muskegon, Mich.

Inspection of Crude, Crystal Michigan, Durbin No. 1

CRUDE

Gravity..... 44.9
Color, Green
B. S. and W..... 0.1%

Distillation of Crude with Gravity of each 10% Cut.

Percent	Temperature	Gravity, A.P.I.°
I. B. P.	72	....
5	122	....
10	170	85.7
20	245	66.4
30	329	56.1
40	402	51.6
50	478	46.4
Yield at 325° F.	...	29.6%
Yield at 395° F.	...	9.5%

A. S. T. M. Distillation of each 10% Cut

	10% Cut	20% Cut	30% Cut	40% Cut	50% Cut
Gravity	85.7	66.4	56.1	51.6	46.4
Odor	O.K.	O.K.	O.K.	O.K.	O.K.
Color	Light Yellow	30	30	30	30
I. B. P.	72	140	230	318	392
5%	84	170	248	338	411
10%	90	174	252	342	417
20%	100	182	258	347	422
30%	109	189	265	352	428
40%	118	196	271	357	434
50%	130	203	279	363	440
60%	142	210	287	370	447
70%	158	218	296	377	456
80%	178	230	308	388	467
90%	.....	248	326	405	485
95%	.....	264	342	423	504
E. P.	243	305	386	451	525
Recovery	88.9	99.0	99.0	98.8	98.0
Residue	1.1	1.0	1.0	1.2	1.5
Loss	10.0	0.0	0.0	0.0	0.5

Tests on Fuel Oil

Gravity...22.9 Flash...460° F. Fire....495° F.
Color.....Green Viscosity @ 100° F. 1340 S. U.

Analysis of crude by Dr. George Van Epps, Chief Chemist, Old Dutch Refining Company, Muskegon, Michigan.

is deposited in this vessel. A fuel-to-charge exchanger is used to bring up the temperature of the oil as high as possible before it enters the pipe still. In addition, before the charge enters the first exchanger it passes through a clover leaf coil in the top of the fractionating column, which serves two purposes; one of controlling the temperature at the top of the column, and reducing the reflux rate at that point, and the other is that of conserving as much heat as possible, which aids in reduction of fuel consumption.

The pipe still was originally a conventional skimming unit but recently has been converted to a special system for production of naphthas. The pipe still contains 90 four-inch alloy tubes made of 4-6 chrome with 0.5 percent molybdenum. The oil is heated to 620°F. before it is flashed to the main column. It enters the column above the sixth tray from the base. The first six trays are used for stripping and into this section a small amount of superheated steam is introduced.

The overhead stream, when describing the operation of the column backwards, is a rubber solvent with 90 to 290°F. boiling range. The next cut is a varnish makers and painters naphtha which is removed from the columns in a rough cut as it enters the side stripping column. This is built with three sections superimposed on one another. The fraction is removed from the fourth to sixth trays of this column, depending upon the closeness of the desired cut, the column temperature and other variables encountered.

The side stripping column is 30 inches in diameter and 70 feet high, fabricated with butt-welded seams as in the larger column previously described. It is equipped with 18 bubble trays, divided into three sections. Reflux is injected into this column as in the larger tower and steam is employed to control the distillation range of the product removed from any of the sections. A predetermined level is carried in the section take-off pan by using an outside liquid level controller. This is a case inclosed float set near the point of take-off which operates a valve in the liquid line.

The first fraction removed from the side stripping column (top to bottom operation) is the VM&P naphtha having a boiling range of 220 to 320°F. The bottom cut, in the same section, is another VM&P naphtha having a boiling range of 310 to 390°F. The liquid level controller in this section takes off the liquid portion, which is the heavier naphtha, while the vapors removed from the top and below the point of reflux injection is the lighter naphtha. Both products are removed through separate lines and run to storage to be blended or disposed of separately after treating.

The fourth fraction taken from the system is a Stoddards naphtha, which is removed from the seventh and eighth trays of the main column. This column is maintained at a predetermined temperature by refluxing with the same material that is removed from it. The take-off points are controlled as with the first operation described, and the column is operated with control valves when it is desired to draw off more from one plate than from another. The temperature at such point is controlled specifically between narrow ranges by controlling the flow of reflux to the point of contact with special instruments. These are flow controllers operating on the pump speed from the reflux leg in the receiving house accumulator.

The fifth fraction removed is a 46° A. P. I. gravity kerosene, taken from trays 12 to 15 in the main column, and stripped in a side-stripping vessel. The sixth cut is a 41.5° A. P. I. gravity distillate, used both as a burning oil and a Diesel fuel. The Diesel fuel made from Michigan crudes, and especially with this method of operation, has a cetene rating of around 70. Gas oil and fuel oil are the other products taken from the system. The gas oil has an average gravity of 33° A. P. I. The fuel oil is marketed to industrial plants in Michigan. Detailed specifications of the various fractions produced are given in Table 1.

Water condensed in the main column coming from steam used in stripped and other process work is taken from the column at the fourth, fifth and sixth trays, counting from the top, and is led to a water leg from which it is removed automatically and

drained to the sewer. Any oil which may be taken from the column during the water separation, is removed from the water leg and placed in slops to be re-run with the crude.

Fuel and plant losses combined do not run over three percent. Wherever possible waste heat is used or recovered. All vapors from receiving house or the run down tanks are accumulated and used as fuel. A small steam compressor is used, which takes the vapors under slight vacuum and delivers them to plant fuel lines to be consumed in the furnaces. Each unit, pipe stills, shell stills and boilers, is fitted with both oil and gas burners.

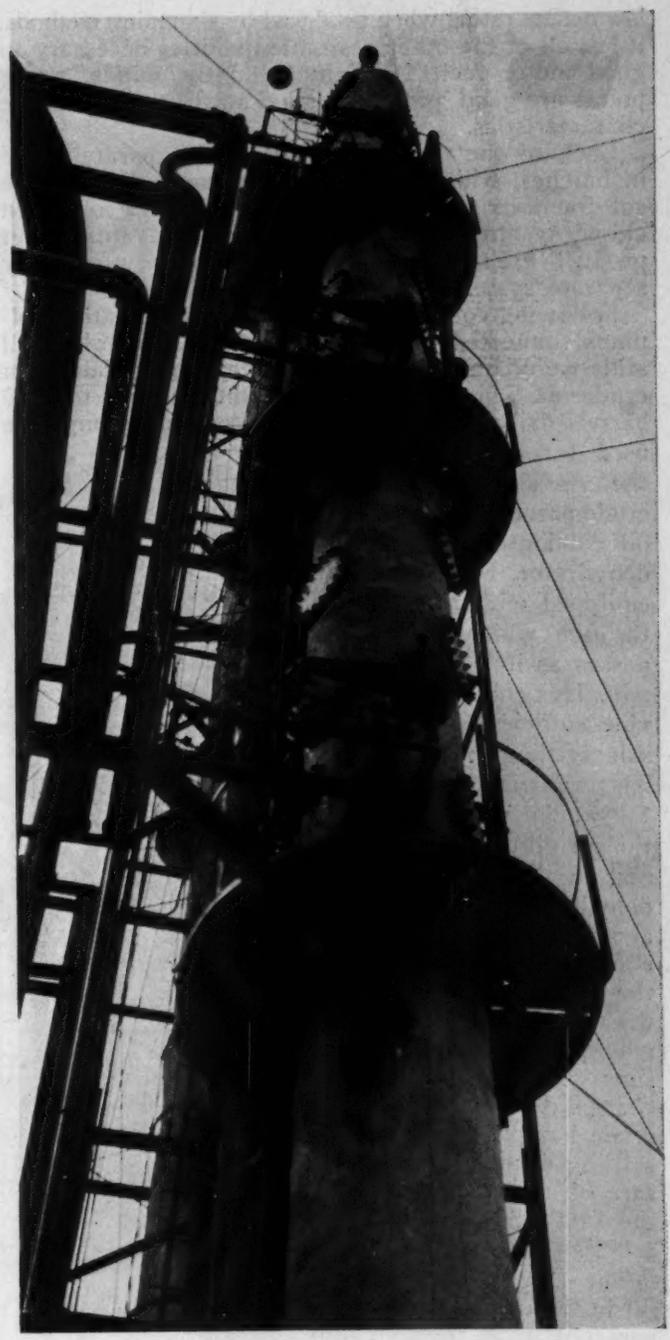
Two water tube boilers are used to generate steam for pumps and for process work. Water circulation pumps are located in the boiler room along with the boiler feed pump. Water used in the boiler is conditioned before entering the water drums. All condensate suitable for boiler feed is saved as the point of condensation and fed back to the boilers to reduce the volume of make-up water.

Some chloride corrosion is encountered in processing Michigan crude, and also there is some hydrogen sulfide to be dealt with. Anhydrous ammonia is used in this plant to combat such corrosion. The ammonia is fed to the top of the column from a large drum placed in the control room. Some high temperature corrosion is present, so flanged and rising stem valves with stainless steel trim, are used. Copper-asbestos inserted gaskets are used where flanges are used, as in gates, or flanged ells or tees. Salt accumulates in the exchangers where crude is passed through the tube and it is occasionally necessary to take them down for cleaning out. Between cleaning periods hot water is sometimes pumped through the exchangers to soften and loosen the softer deposits.

All of the plant products are treated with doctor solution, using agitators which are vapor proof. Michigan crude is peculiarly adaptable to making sweet and stable products. While the gasoline has a very

TABLE 1
Specifications and Analysis of Special Products

Rubber Solvent	
Gravity	75° A.P.I.
I. B. P.	90° F.
50 percent	185° F.
90 percent	242° F.
Recovery	95 percent
Color	30 plus
Odor	sweet
Varnish Makers' and Painters' Naphtha	
Gravity	58.7° A.P.I.
I. B. P.	235° F.
50 percent	265° F.
90 percent	287° F.
Recovery	99.5 percent
Color	30 plus
Odor	sweet
Stoddards Solvent	
Gravity	54.4° A.P.I.
I. B. P.	305° F.
50 percent	325° F.
90 percent	345° F.
Recovery	99 percent
Color	30 plus
Odor	sweet
Kerosene	
Gravity	45.4° A.P.I.
I. B. P.	390° F.
50 percent	452° F.
90 percent	506° F.
Recovery	98.5 percent
Color	30 plus
Odor	sweet
Distillate	
Gravity	41.1° A.P.I.
I. B. P.	465° F.
50 percent	527° F.
90 percent	570° F.
Recovery	99 percent
Color	light straw
Octane Number	70.
Gas Oil	
Gravity	33.7° A.P.I.
I. B. P.	537° F.
50 percent	641° F.
90 percent	750° F.
Recovery	99 percent
Color	straw



Detail of design and operation of the special column for naphtha production is shown in this view.

low octane rating when produced by skimming methods, it has all of the other desirable qualities necessary to good motor fuel. The initial and the middle range points are good, providing good starting and mileage characteristics.

Each of the products are treated separately and in batches, which is necessary because of the close cut fractions manufacture. A continuously operated closed system would serve to better advantage but products are not made in sufficient quantity to justify separate systems for each product.

Following completion of the new fractionating columns connected to the pipe still, the three old shell stills were converted into a battery for operating on crude oil. This increased the plant capacity to 4000 barrels daily. Steam driven reciprocating pumps are used for charging crude to the shell stills. First the crude passes through the gas oil condenser, then to the dehydrator. This is a column equipped with a close coil through which the fuel oil passes as it leaves the final still. This coil is used to provide sufficient heat so that salt settling is accelerated. The crude is heated to about 150°F. in passing through the gas oil condenser section and to about 230°F. in the dehydrator column. In this arrangement the charge is contacted with the heat of the residuum twice; once in the water settler and salt removing drum, and a second time in the bottoms-to-charge exchanger after the crude has passed out of the settling drum. The temperature of the crude entering the first shell still is about 360°F.

The three shell stills are set in the conventional manner. The oil is pumped into the first still and flows by gravity into the next two in line. In the first shell still very little heat is applied for the light stream being removed is a 325°F. end point gasoline. This requires a temperature of around 335 to 350°F. and as the crude enters the still at about that temperature no firing is required.

Vapors from the first shell still are run through a bubble plate dephlegmator set behind the still, with the back trap line leading into the same still. Condensed gasoline is used as reflux over the first column. Vapors are condensed in shell and tube condensers.

The temperature of the second shell still in the battery is held at about 550°F. The vapors from this still pass to a second bubble column and this column is controlled by refluxing to the end that 400°F. end point gasoline is removed. The back trap line leading from this tower, is arranged so that the condensate from the tower bases is returned to the first still in the series.

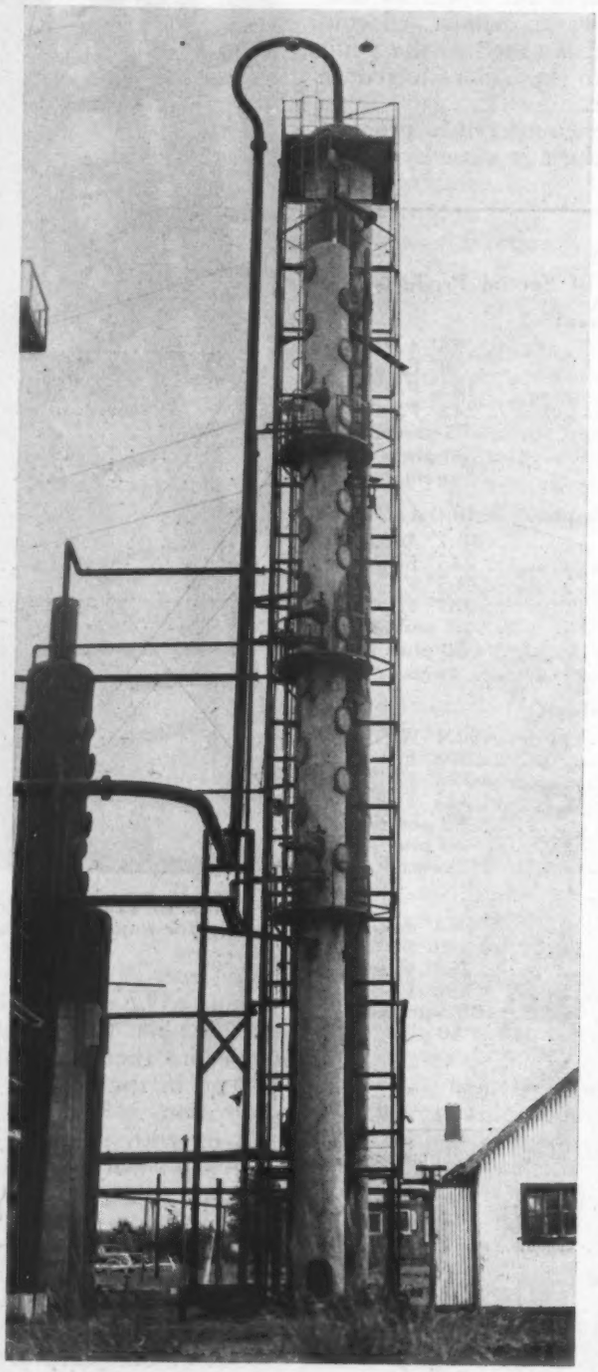
The third still in the series is held at a temperature of about 620°F. Vapors from this still also pass through a bubble column where the stream is broken up into three products. The first fraction removed is a kerosene distillate with a gravity of about 46° A.P.I. and with an initial of about 390°F. and end point of 506°F. The second fraction is removed from the mid-section of the fractionating column. It is a second grade of kerosene with a gravity of 42° A.P.I. The third fraction is a gas oil with gravity of 33.5° A.P.I. All three sections of the column are refluxed to control temperature and to secure the sharp cut fractions desired.

All temperatures are controlled on the three columns by the action of special flow controllers which operate on the reflux pumps. The controllers are set on a board in the pump house where the stillman can readily see what the plant is doing and may easily change the temperatures by adjusting the instrument.

All of the pumps, charging, refluxing and fuel oil evacuating, are lubricated with individual lubricators set on each unit, instead of a central system with piping leading to the pumps. Lubricators of force feed and positive drive type are used.

The fuel oil is pumped from the last shell still after it has been reduced to a gravity of bout 23° A.P.I. and after flowing by gravity through the exchangers and the closed coil in the dehydrator.

By operating the shell stills as an additional skimming unit, and converting the pipe still into a system for production of special napthas, the plant capacity has been increased 100 percent.



Special columns used in Old Dutch Refining Company at Muskegon, Michigan, to make naphthas and solvents.

Naphtha Specialties

At Mt. Pleasant Plant

MT. PLEASANT, Michigan, which is the town around which the oil industry of Michigan revolves, has one refinery—that of Roosevelt Oil Company. This plant was begun in 1930 with small capacity, but has grown to around 5000 barrels per day. Michigan crude is processed, making gasolines, naphthas, burning oils and fuel oil. The crude produced in the Porter field, and that taken from the new Crystal field is refined in about equal portions.

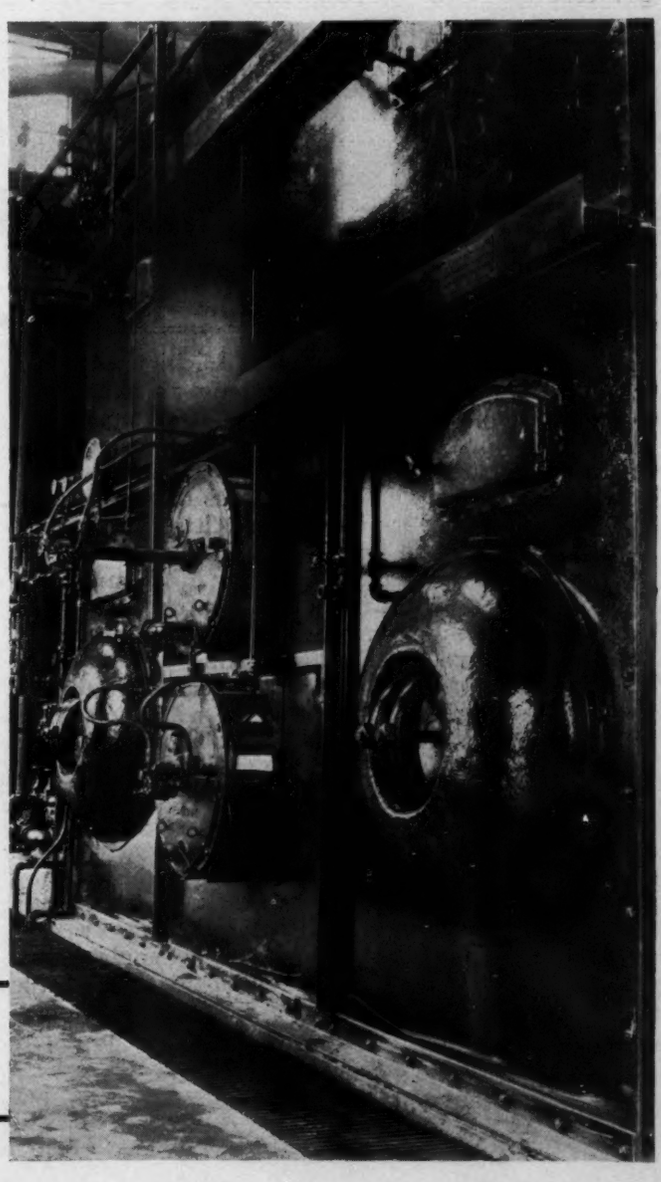
The newer addition, installed about 18 months ago, is a continuous refining plant, taking off close cut products directly from the sides of the columns. The main tower is five feet in diameter by 88 feet high, and contains 36 trays, six of which are stripping, and the remaining 30 used for fractionating the products. Reciprocating pumps are used for charging and reflux control, and to take advantage of all heat, the crude is passed through coils in the top of the main column, the heavier fractions coolers and the fuel oil exchangers. Sediment and salt, which is invariably present in Michigan crude, is removed by passing the charge through a vertical drum before it enters the pipe still.

The pipe still is a conventional unit, heating the oil in process to 590°F., transfer line temperature. It is introduced into the main column above the sixth tray, where it is contacted with live steam and all of the desirable fractions liberated as it travels to the base of the tower. Six cuts are taken from the main column, the overhead of which is the usual straight-run product having a low end point; the next a Stoddard solvent, then kerosene, distillate, UGL gas oil and fuel oil. The overhead product, when cut for motor fuel has a gravity of about 68° A.P.I., an initial boiling point of 102°F., a 50 percent point of 220°F., an end point of 324°F. and a recovery of 94 cc., Engler distillation.

This fraction, when not desired for motor fuel, is introduced into the three-deck, superimposed auxiliary column and separated into two products; rubber solvent and V.M.&P. naphtha. Rubber solvent, taken from the top of the upper compartment of the side column has a narrow boiling range and a color of 30 plus. All products manufactured from Michigan crudes have a remarkable color, with no treatment necessary to bring even kerosene to a water white color. This rubber solvent, the standard grade, is usually of a 70.5° A.P.I., with a boiling range from 107°F. to 289°F.

The V. M. & P. naphtha taken from the base of the upper section has a gravity of about 61° A.P.I., and a boiling range of 190°F. initial, to 312°F., end point. The color of this product is 30 plus and the distillation shows a recovery of 99 percent. These two products are taken from the side stripper, which is a column 36 inches in diameter by 36 feet in height, insulated to prevent radiation of process heat to the atmosphere.

This column is virtually a three-column side strip-



Firing front in the boiler room at Roosevelt Oil Company's Mt. Pleasant plant.

per, having the three compartments superimposed upon the other merely for convenience and to conserve space. Each section is 12 feet in height, with no connecting down comer or wier control between. Each section is provided with superheated steam connections as well as process steam lines so the products received from the main fractionating column to the particular side stripper section may be processed to special gravity and boiling range at the time of refining, rather than rerun to secure the necessary specifications.

The vapors removed from the overhead line on the main fractionating column are condensed before being introduced to the top section of the special products fractionator, and the end point is controlled by returning a portion of the condensate back as reflux. If an especially low end point, close boiling range naphtha is desired, the reflux is pumped in greater quantities, so the resulting re-run, or refractionated products, can be taken from the special products column with the desired specifications.

By adjusting the amount of steam in the special column, and the steam in the draw-off pans of the main fractionating column, any desired fraction may be readily removed from the plant without serious difficulty. When making the standard products, the percentages of products are as follows:

Products	Yields Percent
Rubber solvent	17
V. M. & P.	7
Stoddard solvent	10
Kerosene	10
Distillate No. 1	11
UGI. Gas Oil	13
Fuel Oil	30
Total	98
Gas and loss	2
	100

The average loss when running Michigan crude is apparently much larger, running on an average of about 3.6 percent, but Roosevelt Oil Company has installed a vapor recovery unit which processes the vapors from the rundown tanks, accumulators and other vessels, which has reduced loss to two percent. All tankage has vapor-proof covers, fitted with vapor-proof vents and thief hatches.

All products manufactured from Michigan crude oil must be treated, because of sulphur content, which causes the gasolines and other special naphthas to be sour and corrosive. Doctor treating plants are the rule generally, and this company uses agitators in which the special cuts are contacted with the sodium plumbite. The gasolines and naphthas react to this form of treating readily, and are finished with a good odor, and color. Some purchasers of special naphthas specify that the products received by them must show a slight tinge of color on the copper strip when treated, which more or less complicates the treating program. To secure a product sweet, and only corrosive enough to slightly discolor the copper strip without going into the peacock colors requires delicate adjustment of the flow of chemicals and the time of contact.

If the anti-knock rating of straight-run products was sufficiently high, a high yield of gasoline could be secured at this plant. But as the octane rating of Michigan gasolines ranges from about 23 to as high as 55 in exceptional cases, this makes a 400 end point motor fuel somewhat undesirable. To secure a gasoline having qualities which may be improved upon by blending with benzol and other products, the end point of motor fuels is held to about 325°F. An analysis of the two crudes run by Roosevelt Oil Company is given in Table 1.

TABLE 1
Crude Analysis

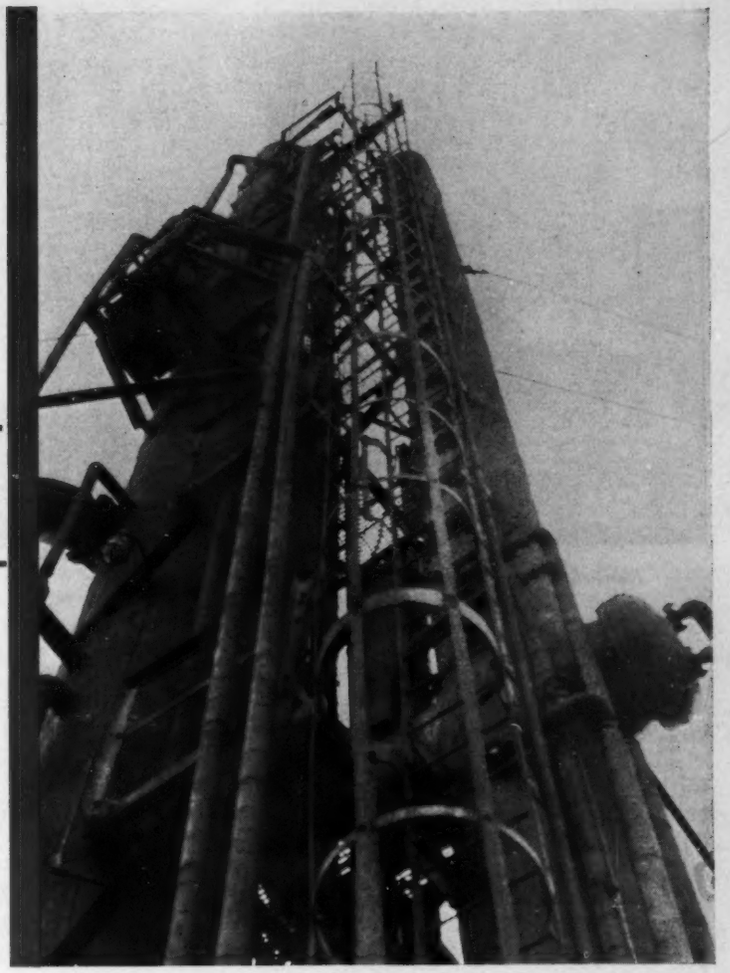
Distillation	Field Porter	Field Crystal
A.P.I. Gravity	41.8	44.9
Sulphur, percent	0.19	0.35
I. B. P.	114°F.	100°F.
5 percent	186°F.	148°F.
10 percent	229°F.	188°F.
20 percent	305°F.	257°F.
30 percent	379°F.	320°F.
40 percent	444°F.	400°F.
50 percent	509°F.	475°F.
60 percent	576°F.	560°F.
70 percent	665°F.	648°F.
80 percent	713°F.	688°F.
90 percent	730°F.	712°F.
Final	754°F.	750°F.
Over 400°F.	33.5 percent	40.0 percent
437°F.	39.0 percent	45.0 percent
Total recovery	97.0 percent	96.0 percent
Coke, by weight	2.2 percent	2.9 percent

From the above analysis, the two crudes handled show a difference in lighter components, which causes a greater gas loss when processing Crystal than when refining Porter crude. The No. 1 distillate refined from crude handled by this plant shows the following:

Gravity, A. P. I.	46°
I. B. P.	348°F.
5 percent	376°F.
10 percent	384°F.
20 percent	400°F.
30 percent	414°F.
40 percent	430°F.
50 percent	448°F.
60 percent	466°F.
70 percent	480°F.
80 percent	498°F.
90 percent	520°F.
95 percent	534°F.
Dry	560°F.
E. P.	588°F.
Color	Prime
Flash	(Pensky-Martin) 146°F.
Pour	—36°F.

One of the peculiar points about this distillate is that while having a pour test quite low, the paraffin crystals begin to appear immediately below that point, and form rapidly to an almost solid mass at about 39 to 39°F. below zero.

Cracking has not been attempted by Roosevelt Oil Company, but either gas oil or reduced crude may be processed shortly. Some consideration has been given to the erection of a cracking unit, but octane rating is hard to secure, even with cracking. Yields are easily obtained, but to secure a satisfactory octane rating on the cracked gasoline, large gas losses are said to occur.



Column and side stripping special column in plant of Mid-West Refineries, Inc., Alma, Michigan.

Midwest Plant

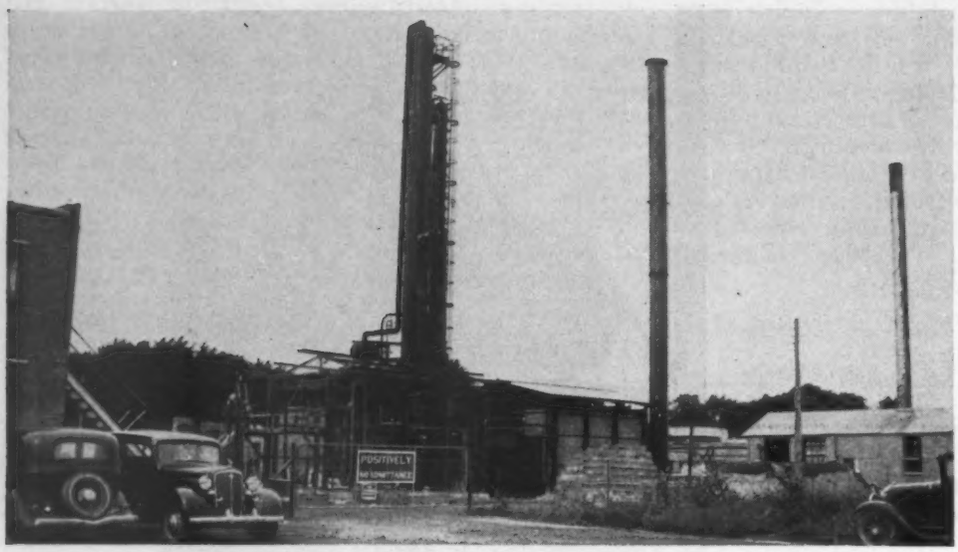
Designed for Special Products

MID-WEST Refineries, Inc., finished building a skimming plant at Alma, Michigan, and placed it in operation in July, 1934, and in July, 1935, began erection of a companion unit which will double the capacity of the refinery. The capacity of both units when running at normal crude charge will be about 3000 to 3500 barrels per day.

Like other skimming plants operating in Michigan, the most profitable products are special naphthas. Further like other plants operating in Michigan, the products are removed from the side of the fractionating column, received in side strippers, but unlike other plants, the streams taken from the side strippers are controlled while in the distillate lines and metered directly to the run-down tanks.

The usual method is to control the volume of the side cuts by the operation of liquid level controllers, which hold a certain predetermined level on the pans, permitting the liquids desired to flow into the vapor and liquid lines as they build up on the pans. The method used at this plant controls both the quantity and the quality of the side streams at the same time. Displacement meters are set in the control room directly in the rundown lines. These meters are calibrated to accurately register the volume of distillate, and are backed up by gate valves which are manipulated to control the volume of distillate and condensate passing through the meters.

The plant is more or less conventional in its arrangement, as to the general layout of the equipment, but in the beginning provisions were made for enlarging the plant by arranging the tract of land, and by locating the tankage and other accessories. The plot was selected on the side of the railway so



General view of Mid-West Refineries, Inc., plant at Alma, Michigan.

the loading rack, the team track and other spurs could be built with the idea in view of providing convenience for refinery construction and operation.

The pipe still built with the first unit is equipped with two-inch carbon steel tubes fitted with special tube headers. The second unit, now building, is equipped with three-inch carbon steel tubes, fitted with the same kind of headers. Special cast ferrous alloy tube supports were made for the furnaces and combination gas and oil burners installed. The unit was designed and engineered by Leader Industries, Inc.

The oil charged to the plant comes from the new Crystal Township field through a newly laid pipe line. This crude is better than the average Michigan crude oil, because of the higher octane rating of the straight-run gasoline.

The main fractionating column used with the first unit is 84 feet high fitted with 25 bubble trays, seven of which, located in the lower section, are used as stripping trays. All of the products removed from this column are passed through primary condensers, or coolers, which are also used as heat exchangers. The crude flow follows first through the exchanger on the overhead stream and continues through the remaining exchangers which serve the kerosene, distillate, gas oil and fuel bottoms. In this way, all available heat is used in preparing the oil for processing, as well as removing heat from the products before they enter the secondary coolers or condensers. In Michigan, this is an important phase of operating a refinery, because for several months, the temperature drops to sub-zero levels, making it quite a task to circulate water without a freeze-up in some part of the system.

Because oil produced in Michigan carries a considerable amount of salt in suspension, even with water practically absent, it is necessary to provide a settling drum for its removal. Some plants locate the salt settling drum before the oil is heated by the residuum from the base of the flash column, but this company passes the charge through all of the exchangers before the oil enters the pipe still. Removal of the salt is the object in mind, and the method is more or less a minor subject.

A steam driven reciprocating unit is used to pick up the oil from the working storage and deliver it through the primary condensers on the side streams and to the pipe still. The still is equipped with two banks, the radiant section in the roof, and the convection section in the side. After the oil is passed through the pipe still it is immediately flashed in the lower section of the main column, where a sufficient amount of steam is used to obtain adequate stripping.

Because of the relatively small demand for straight-run gasoline manufactured from Michigan crude oil, the column was designed so several rather close cut fractions could be removed. Six streams are taken from the tower, the overhead stream being either a gasoline, cut to specifications (usually with a low end point) which may subsequently be re-run through a side stripper, or auxiliary tower which splits the stream into rubber solvent and naphtha. The octane rating of a straight-run gasoline, having a distillation range specified as U. S. motor gasoline, is usually so low that it finds no market, consequently the average end point of Michigan straight-run gasoline is about 350°F. or lower.

Wet reflux is pumped back over the column to control the quality, as well as the quantity of the overhead fraction, which is picked up from the condensate accumulator, or the run-down tank. Stoddard solvent is taken from the twenty-second tray, and is received in a side stripping column, where the specifications are met by using steam to vaporize the more volatile fractions before the finished product is passed through the coolers. By varying the operation of the column and the side stripper, the resulting distillate can be fractionated to either a standard Stoddard or into a special cut when orders are received for a product which does not conform to the usual distillation range.

The quantity of the overhead cut from the main column is governed by the quality of the crude, which in turn is fixed more or less by the field from which it is produced. When a 350°F. end-point product is recovered from the column, the quantity is about 23 to 25 percent, if the charging stock comes from the Crystal field. In turn, this cut, when separated into rubber solvent and VM&P naphtha runs about 17 percent rubber solvent, and about seven percent VM&P. If a gasoline is desired which has a relatively high octane value, the percentages are less, because the higher the end-point, the lower the octane value of the product. Octane values vary considerably, running from as low as 25, to as high as 55, motor method. These values were obtained from a 400°F. end-point gasoline, having a gravity in some instances as high as 64° A.P.I.

When cutting the overhead stream into the two special products, rubber solvent and VM&P naphthas, the entire overhead cut is condensed and fed subsequently into the special column, which has 20 fractionating plates. The product is fed through a preheater into the column above the eleventh tray.

The composite feed is heated again in the base of the column which controls the distillation range of the bottom product. The overhead stream, being a close cut product suitable for rubber solvent, is controlled by refluxing the column with the condensate.

Standard Stoddards, or the special products falling in the range of Stoddards are removed from the column, being taken from the twenty-second tray, and, upon entering the special Stoddard stripper, are treated with steam to control the initial boiling point. The equilibrium of the tower is such that the end-point of this product is approximately uniform, but in drawing off the cut, the initial must be controlled. The yield is about 10 percent.

The next three cuts taken from the main column direct are kerosene, No. 1 distillate and No. 2 distillate. These fractions are the ones which are controlled by the special metering devices placed in the control room. The cuts are taken from the column from the eighteenth, fourteenth and eleventh trays, in the order named. The streams are condensed and cooled in the conventional manner, and are led to the control room through piping dropping from the condensers overhead, to the side of the building, where the samples may conveniently be removed for analysis in the laboratory.

Each of the three lines is equipped with displacement meters which have been calibrated to record, or measure accurately, the product which flows through them. By a set of experimental runs, the volume of these distillates from any given crude are calculated and are known to be taken from the column at a certain rate per hour. Back of the meters are placed the control gates by which the operator can control the volume of distillate being received and measured by the meters. From information accumulated during the experimental runs, when the plant was first placed in operation last summer, the plant operating personnel knows that with a certain given volume being measured by the meters, the quality of the product will be approximately, if not exactly correct. By varying the amount of distillate being drawn off from the main column, any discrepancies in the fractional analysis of the products can be remedied.

The excess product distilled from the crude and collected on the draw off pans is permitted to flow over the wiers to the fractionating plates below and to be further rectified. By controlling the three cuts in this manner, each is said to be received in such condition that they meet the buyers specifications for that grade of distillate. It is also said by the operating personnel and the designing engineer, that the entire plant can be fired up from a cold start, and streams of the desired specifications removed from each draw off pan within five to six hours. This speed is attributed to the fact that the four lower streams can be set to volume in the receiving house by the block and control valves, and the meters disclose to the operator the rate of distillation and fractionation.

The entire plant has been balanced from a power standpoint so that the steam generated will serve its purpose without loss of condensed water. Electric motors are used to drive some of the pumps so that an undue load may not be placed upon the steam generating unit. Rotary pumps are used for transfer units, driven by 10 horsepower electric motors, through a double gear arrangement and clutches, so each pair of pumps may be operated simultaneously, or only one used at a time.

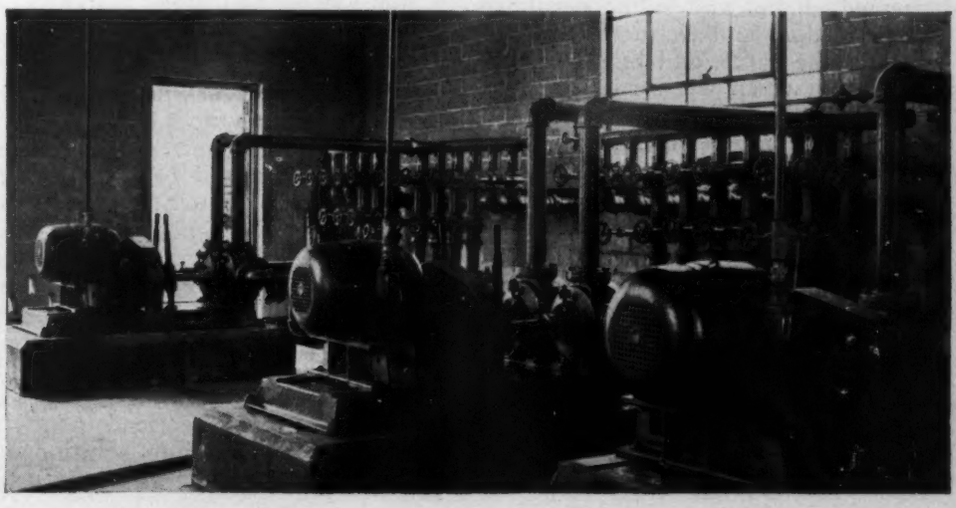
The new unit, which will be in operation soon, will be a replica of the first, except the size and capacity. Larger tubes are used in the second unit, with a corresponding increase in the size and capacity of the fractionating equipment. The special controls on the heavier cuts removed from the main column will be of the same type and arrangement as those on the first unit. By keeping the units separated, each may be operated on a different crude, with products cut to specification, and each plant can be run to produce a variety of special cuts. They will be charged separately, fired and controlled separately.

Through an operating subsidiary, Mid-West Pipe Line Company, the refinery has a supply of crude coming from several fields at the same time. Each crude is kept in the plant storage unmixed with other crude, because of the difference in octane value of the gasoline manufactured.

Michigan distillates have an especially good color when taken from the columns and untreated. The distillation ranges compare favorably with similar products manufactured from other crudes, but contain some sulfur impurities which are removed before shipment. The usual method of sweetening the distillates is to use sodium plumbite, contacted with the gasolines and other products in an agitator.

Corrosion is expected to become most active on the overhead streams, therefore anhydrous ammonia is introduced into the vapor line immediately after it leaves the column. By using ammonia in certain predetermined amounts, it is expected the low temperature corrosion, caused by chlorides and sulfur compounds will be materially decreased.

Interior plant general transfer pump house, with electric driven rotary pumps.



Sweetening With Plumbite

C. W. BERGER

Research Chemist, Globe Oil & Refining Company, McPherson, Kansas

DOCTOR sweetening with caustic plumbite solution, both in continuous treaters and batch agitators, is today, in spite of its simplicity, an art often jealously guarded by men experienced in this department of refining. Years of experience, exposure to all types of sweetening problems, and tricks picked up from others in the same business, comprise the average treater's bag of magic. Trial and error, hit or miss, yet the treater gets the job done to everyone's satisfaction in the end, and woe to those who ask him the "why" or the "how" of his methods.

Scientific study of treating problems has, however, disclosed many facts that are unquestionably of interest to those engaged in sweetening operations, and provides the "why" and "how" to many sweetening problems. A full understanding of what goes on in the treating tower or the batch agitator is, or should be, prerequisite to any treater's honest effort toward improving himself or his job. It is the object of this paper to take up sweetening operations from both the practical and the scientific viewpoints simultaneously.

In the first place, the object of doctor sweetening is to free the sour gasoline or kerosene of mercaptans. Mercaptans are thio alcohols, or alcohols in which the oxygen is replaced by sulphur. A simple illustration of this is given.

C_2H_5OH Ethyl Alcohol
C_2H_5SH Ethyl Mercaptan

Ethyl mercaptan and its brother and sister mercaptans, are characterized by their very disagreeable and sickening odor, an odor commonly called "skunk like" and rightly so because the skunk's method of defense is based on mercaptans and other very similar compounds. The same reason that a skunk's odor can be detected miles away, causes extremely minute quantities of mercaptans to be noticeable in gasolines.

Not all mercaptans are as simple in structure as is ethyl mercaptan; some have large formulas with branched chains and other peculiarities, and have different odors and characteristics, but they are all basically the same, and by far the largest majority of those in which we are interested have the property of reacting with caustic plumbite, causing the gasoline containing them to be "sour" to the doctor test.

DETERMINATION OF MERCAPTAN CONTENT

Since not all gasolines and kerosenes contain the same amounts of mercaptans and since the treating life of doctor solutions depend on the amounts present, it should be of interest to the treater to know what relative amounts of these substances are present in the type of petroleum distillate he is sweetening. It will explain "why" distillates from some sources require more lead and caustic for treatment than others. Several good methods have been evolved for the determination of mercaptan content; some are quite lengthy, others quite inaccurate. The following method is quick and reasonably accurate and should be in the files of petroleum chemists:

Titrate 100 cc. of sour, H_2S free, gasoline in a 250 cc. separatory funnel, with a copper sulphate solution containing one gram of copper per liter. Add one cc. at a time. The blue color of the copper solution will disappear immediately upon shaking the funnel until the end point has been reached. Every cc. used means millegrams of mercaptan sulphur per 100 cc. of gasoline.

In making up the copper solution, dissolve (for example) 3.91 grams of $CUSO_45H_2O$ in 300 cc. of water and chill in ice. Add chilled 5° Baume caustic soda slowly until there is no further precipitation. Add chilled ammonium hydroxide until all the precipitate has dissolved, and dilute to one liter with distilled water. The solution must be kept ice cold during the entire operation, and if there is any dark precipitate in the flask when finished, the solution is of no value.

Knowing the relative amounts of mercaptans in his stocks, the treater can more easily estimate the amounts of plumbite and of sulphur that will be required to treat them. This is of particular benefit to batch treaters in that they can have an idea as to the amount of sulphur that will be necessary for their agitator. Agitators can often be more easily treated if most of the sulphur is added before the doctor, and the former put into intimate solution.

Let us examine the treating process step by step and point out what happens in each case. In the first place, doctor solution is made by dissolving litharge (lead mono-oxide) in caustic soda, the lead going into solution as sodium plumbite, the active agent in sweetening processes.

$$PbO + 2NaOH \rightarrow Na_2PbO_2 + H_2O$$
Litharge + Sodium Hydroxide = Sodium Plumbite + Water

Inasmuch as there is always an excess of sodium hydroxide present, the sodium plumbite is always in solution in caustic soda.

When doctor solution, containing sodium plumbite, is contacted with sour gasoline containing mercaptans, the gasoline becomes orange or brown in color from the reaction between the plumbite and the mercaptans.

$$Na_2PbO_2 + 2C_2H_5SH \rightarrow \begin{matrix} C_2H_5S \\ C_2H_5S \end{matrix}\!\!>Pb + 2\,NaOH$$
Sodium Plumbite + Ethyl Mercaptan = Lead Mercaptan + Sodium Hydroxide

Ethyl mercaptan has been used here as an example. The lead mercaptide formed, usually has an orange color and is the reaction product of the plumbite and the mercaptan.

When free sulphur is added to the gasoline containing lead mercaptides, its action is to oxidize the mercaptides, thus completing the sweetening reaction.

$$\begin{matrix} C_2H_5S \\ C_2H_5S \end{matrix}\!\!>Pb + S \rightarrow PbS + \begin{matrix} C_2H_5S \\ C_2H_5S \end{matrix}$$

A black precipitate of lead sulphide is formed, this phenomenon usually being called a "break", and also disulphides are released and go into solution in the gasoline. These disulphides are similar in structure to the original mercaptans but do not have the unpleasant odor, are not corrosive, and do not react to the doctor test. Thus a gasoline or kerosene in which the mercaptans have been changed to disulphides is called "sweet".

There are many other less important reactions involved, including the formation of basic mercaptides, the reactions of lead hydroxide, caustic soda, and the questionable sweetening reactions of lead sulphide itself, but these will not be discussed because we are interested only in the basic principals of the sweetening reactions in this article.

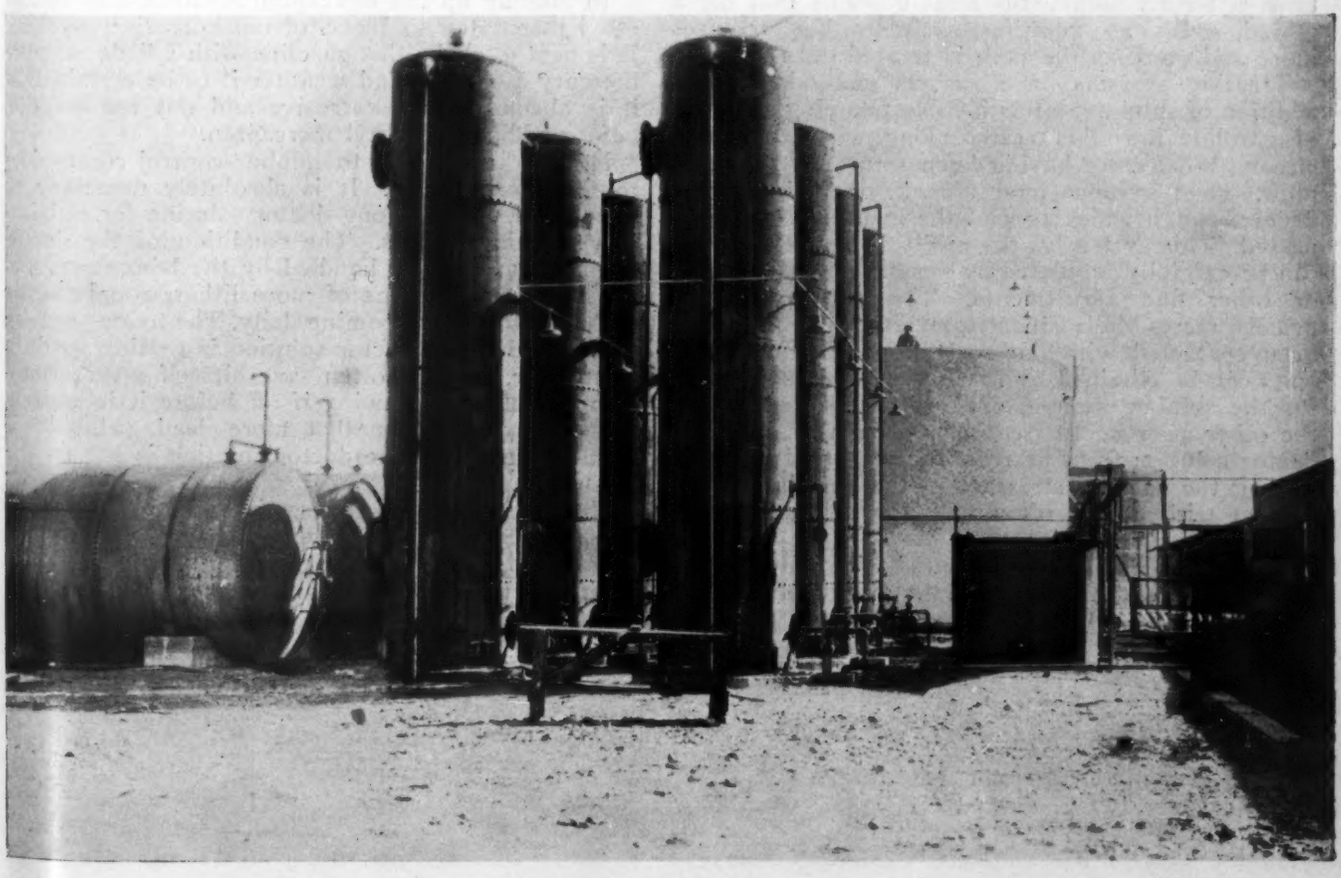
The lead sulphide formed, as indicated in the last equation, often becomes emulsified with some of the gasoline and caustic soda present and is then known as "black strap". This black strap is pumped, along with the spent doctor solution (mainly caustic soda) to recovery tanks fitted with open and closed steam coils and with compressed air coils. Here the emulsion is heated and blown with air to oxidize the lead sulphide to lead sulphate.

$$PbS + 2O_2 \rightarrow PbSO_4$$

Lead sulphate is soluble in caustic soda and goes back into solution as sodium plumbite, thus regenerating the doctor solution for further use.

$$PbSO_4 + 4NaOH \rightarrow \underset{\text{Sodium Plumbite}}{Na_2PbO_2} + \underset{\text{Sodium Sulphate}}{Na_2SO_4} + 2H_2O$$

It will be noticed that more sodium hydroxide must be added to put the lead sulphate in solution. In practice, an excess of caustic soda is always maintained, more being added as the solution becomes weaker. It will also be noticed that in the last equation, sodium sulphate is formed. This salt, along with sodium thiosulphate and calcium and magnesium salts from the water used, gradually build up a concentration in doctor solution. They increase the gravity but are inactive as sweetening agents. For this reason, gravity tests often mean little in doctor solution—the percentage of litharge and caustic should be analyzed in the laboratory. Further, this concentration of salts often makes it necessary



to throw away batches of doctor solution after many regenerations.

In the recovery operations, if they are as described above and do not incorporate some intermediate system of separating naphtha from the black strap, steps must often be taken to prevent regenerated doctor solution from throwing fresh gasoline off color. The naphtha pumped into the recovery tank with the caustic soda and lead sulphide is theoretically all boiled away by heat and by the use of live steam, which effectively lowers the vapor pressure of the naphtha and carries it into the atmosphere. Heavy naphtha ends, however, have a tendency to remain in the doctor, forming a scum around the lead sulphide, preventing the latter from going into solution, and providing a medium for off colored hydrocarbons to remain in the doctor solution. Only by strong heating and blowing and long settling can these heavy ends be eliminated. There are, of course, other systems for gasoline removal from black strap such as centrifuging, burning, and treatment with emulsion breakers.

In continuous treating, there are a good many maneuvers that will improve the finished product. Careful control of the addition of free sulphur is probably the most important.

In continuously sweetening tanks of gasoline from the same crude, less sulphur is needed in certain cases. This is usually because the sour gasoline, containing hydrogen sulphide, has been allowed to set for a longer period in run-down tanks, thus giving the hydrogen sulphide an opportunity to become exidized to free sulphur and the sulphur to become dissolved in the gasoline. Free sulfur from the roofs of run-down tanks sometimes falls into the gasoline and floats at the interface of the oil and water layers in the tank, gradually going into solution in the gasoline. Taking suction from near the bottom of the tank, a treater sometimes finds gasoline that for a period, needs no additional sulphur but requires more and more as the tank is treated out.

Treating systems have various methods for the addition of sulphur; a few involve pumping a stream of gasoline into the treater along with the main stream, the former having been saturated with sulphur. Most systems have a rock, or stick sulphur drum through which part of the main stream is bypassed. This system works nicely if the side stream can be carefully regulated by means of needle valves or other fine adjustments. The sulphur stream usually meets the main stream after the latter has been contacted with doctor solution. Different results can be obtained by having two points of entry for the sulphur stream, one before doctor contact, the other after it. In treating with a fresh batch of doctor solution from new caustic soda and litharge, cutting the sulphur stream into the gasoline before contact with doctor often will give a much faster "break" than otherwise.

The writer was once confronted with the problem of poor sun stability on straight-run gasoline after doctor treatment. Hand treated batches were sun stable. The difficulty was traced to improper "breaking" of the stream by sulphur, this causing a carry-over of doctor solution and lead sulphide along with sodium phenolates and other organo-acidic bodies, into the water wash mixer. The latter served mainly to emulsify the whole instead of properly washing the gasoline. By increasing the number of orifice mixers in the doctor mixer and in the water mixer, and by getting a much better initial break, the difficulty was overcome. This entailed running the gasoline slightly corrosive for a few minutes after the treater started and gradually cutting down the sulphur stream when the various streams became properly adjusted to the type of gasoline. This manipulation should be considered good practice for other reasons also, since, when applied to all the continuous treaters, it eliminated carry-over of lead sulphide and caustic into the sewer.

In attempting careful sulphur control, the treater often is troubled because it requires at least 20 or 30 minutes for him to determine whether or not his stream is corrosive if he runs corrosions by the usual copper strip method at 212°F. Some plants use metallic mercury and estimate by the amount of black mercury sulphide formed when the gasoline is shaken with the metal, whether or not the gasoline is corrosive. A much more accurate method is submitted:

Filter about one half-inch of the gasoline into a four-ounce bottle and add the same amount of clear doctor solution. Add one cc. of ethyl mercaptan solution and shake vigorously. If the gasoline is non-corrosive, particles of free sulphur will be seen floating about on top of the doctor. If the gasoline is "off strip", you will get a dark brown or black discoloration. This test is as easy to make as a doctor test and differs from it only in that ethyl mercaptan is used instead of a pinch of sulphur.

In making up the mercaptan solution, add 1cc. of ethyl mercaptan to 100cc. of non-corrosive gasoline. It is best to shake this gasoline with a little metallic mercury and filter and weather it to be certain that it is absolutely non-corrosive and not too volatile, before adding the ethyl mercaptan.

Next in importance to sulphur control comes doctor solution control. It is absolutely necessary to have good, clean, strong doctor solution for satisfactory treating results. The condition of the doctor solution can best be handled by the laboratory, and advice as to additions of more litharge and caustic soda should be forthcoming daily. The treater usually can tell when his doctor solution is getting weak in his treater, and can often save himself severe emulsion troubles by drawing if off before it is entirely spent, for the reason that more lead sulphide is formed the longer the doctor solution is left on the treater.

Unquestionably, doctor treating with sodium plumbite is simple and yet interesting, especially if one knows and understands the hidden reactions that go on inside the treating towers.

Rapid Volumetric Method

FOR DETERMINING

Lead in Doctor Solution

RUSSELL M. LILLY

QUANTITATIVE determination of lead by any method is a very unsatisfactory procedure as regards speed, ease, and convenience of manipulation. The methods of analysis most commonly employed are gravimetric, and are consequently tedious, time consuming operations, requiring an interval of several hours between sampling and the final result.

Because of time consuming characteristics and other objectionable features of gravimetric methods, considerable effort has been expended by various investigators in an attempt to devise a rapid and satisfactory volumetric procedure for determination of lead, but as yet no thoroughly satisfactory method has been evolved.

Recent developments in the science of analytical chemistry have brought into practical use very satisfactory internal oxidation-reduction indicators. Since use of these valuable indicators greatly increases the scope of practical analysis by oxidation-reduction methods, the writer decided to investigate the possibility of applying them to the volumetric determination of lead, particularly as applied to the determination of lead in doctor solution.

After careful study of the characteristics of indicators available, analytical procedures were devised which attempted to make use of individual qualities of two most promising prospects. The chemical reactions involved are exactly the same in both instances, but since the end-points must be approached from opposite directions in order to get sharpest color changes, procedures were altered accordingly.

Experimental. — In order to test the accuracy and practicability of the methods proposed, a solution of the internal oxidation-reduction indicator sodium diphenylamine sulfonate was prepared and the indicator solution ferrous ortho-phenanthroline complex was purchased.

A solution N/10 in lead value was prepared by weighing out the calculated amount of the purest lead nitrate obtainable and carefully checking normality by gravimetric determinations.

Approximately N/10 solutions of ferrous ammonium sulphate and potassium dichromate were prepared and their relationship to each other determined according to approved volumetric procedures.[1]

The solution of ferrous ammonium sulphate was standardized against known amounts of the standard lead solution and according to the following procedure: The lead was precipitated as $PbCrO_4$, filtered, washed free from soluble chromates and dissolved in dilute HCl. The dilute hydrochloric acid transposes the $PbCrO_4$ into lead chloride[2] and di-chromic acid. The chemical reaction may be written as follows:

$$2PbCrO_4 + 4HCl = 2PbCl_2 + H_2Cr_2O_7 + H_2O$$

The di-chromic acid formed was reduced by an excess of the approximately N/10 ferrous solution, the excess then being titrated with N/10 potassium dichromate using sodium diphenylamine sulfonate as internal indicator. The chemical reaction may be written

$$H_2Cr_2O_7 + 6FeCl_2 + 12HCl = 2CrCl_3 + 6FeCl_3 + 7H_2O$$

The normality of the ferrous ammonium sulphate, as arrived at in this manner, was used in a series of determinations against known amounts of the standard lead solution. The results tabulated in Table 1 proved that results could be reproduced with a high degree of accuracy and with speed and ease of manipulation unapproached by other methods.

TABLE 1

	Lead content calculated gravimetrically	Lead content determined volumetrically
1.....	0.1036	0.1038
2.....	0.1036	0.1037
3.....	0.1243	0.1241
4.....	0.0829	0.0831

When attempting to quantitatively determine the lead content of old and reclaimed doctor, considerable difficulty was encountered due to its containing high concentrations of such impurities as carbonates, sulfates, thiosulfates and numberless organic compounds that defy description. The influence of these complicating substances is very apparent when precipitating the lead directly from the original solution with potassium dichromate. The boiling hot, acid solution of $K_2Cr_2O_7$ apparently oxidizes some of the organic compounds present to form gelatinous, scum-like materials which render filtering difficult and which occludes sufficient foreign matter to throw the results considerably in error.

These complicating substances were removed by precipitating the lead directly in the caustic solution by addition of a soluble sulfide and diluting largely with warm water. The lead sulfide precipitate is large and coarse grained and settles almost instantly. The supernatant liquid is then decanted through a coarse, fast filtering paper and discarded, immediately eliminating the vast bulk of all interfering substances. The precipitate is then dissolved in boiling hot dilute nitric acid, neutralized with ammonium hydroxide and precipitated with potassium dichromate.

This preliminary precipitation as lead sulfide is

unnecessary when the doctor is new or reasonably clean.

A complete detailed procedure is described as follows: Pipette 10cc. of doctor solution into a clean beaker, add 10cc. of a two percent solution of Na_2S dilute largely with water and allow to settle while preparing the other samples. Decant the supernatant liquid through a coarse, fast filtering paper, keeping the bulk of the precipitate in the beaker. It is not necessary to wash the precipitate.

Place beaker and precipitate under the funnel and dissolve the precipitate by pouring through the filter about 25cc. of boiling hot dilute (about 3/N) nitric acid. Re-heat, if necessary, to completely dissolve the precipitate in the beaker. Remove the small amount of free sulphur that appears by filtering through the original paper into a clean beaker.

Add ammonium hydroxide (5 or 7.5/N) to the filtrate until the faint permanent appearance of a precipitate; dissolve with one or two cc. of glacial acetic acid. Dilute to 150cc., heat to the boiling point and add 10cc. of a five percent solution of potassium dichromate. Boil gently for several minutes and allow to settle completely while preparing the other samples.

Decant the supernatant liquid through a filter and wash the precipitate with water until free from soluble chromates. Discard the filtrate. Stir up and dissolve the precipitate on the filter with a fine stream of dilute HCl[3] (5 or 7.5/N) from a wash bottle. Wash the filter once or twice with water. It is unnecessary to polish the beaker. The titration takes place in the same beaker and by washing down the sides with dilute HCl the adhering precipitate is dissolved.

From a pipette (or burette) add to the filtrate 25cc. of N/10 ferrous ammonium sulphate, 10cc. of phosphoric acid and six drops of sodium diphenylamine sulfonate. Titrate the excess ferrous solution with N/10 $K_2Cr_2O_7$, and as the end-point approaches, add dropwise. The end-point color change is from pale yellowish green to intense purple, rivaling in brilliancy the starch-iodine reaction.

ALTERNATIVE METHOD

Alternative procedure using ferrous ortho-phenanthroline indicator:

Dissolve lead chromate in dilute HCl, add 10cc. of phosphoric acid and titrate directly with the N/10 ferrous solution until the color of the solution almost disappears into the green of chromium chloride, add one drop of ferrous ortho-phenanthroline complex indicator and titrate carefully until the bluish green of the solution turns sharply to red. The end-point occurs instantaneously and gives little warning of its approach.

Table 2 shows the results of a series of determinations by this method using old and reclaimed doctor with lead content determined gravimetrically and found to be 0.0925 g. per 10cc.

TABLE 2

	Lead content calculated gravimetrically	Lead content determined volumetrically
10cc.	0.0925 g.	0.0929 g.
12cc.	0.1110 g.	0.1117 g.
15cc.	0.1388 g.	0.1395 g.
10cc.	0.0925 g.	0.0928 g.

The accuracy obtained was well within one percent, which is better than is ordinarily expected of the average routine analysis of this kind.

The determinations were invariably slightly high, due, probably, to difficulty in washing out the last traces of soluble chromates.

Such aids to super-accurate work as weight burettes, temperature and indicator corrections were not used in these experiments.

The volume of titrated solution should be kept low (under 150cc. if possible) because only a given amount of color is created and it is obvious that the greater the dilution, the less-intense the color.

The sodium diphenylamine sulfonate used as the indicator is prepared by dissolving 0.32 grams of barium diphenylamine sulfonate in 100cc. of distilled water, adding 0.5 gram of sodium sulfate and filtering or decanting the clear solution from the precipitated barium sulfate.

The ferrous ortho-phenanthroline complex indicator must be purchased on the market. This indicator is very satisfactory when used with the stronger oxidants such as ceric sulfate and potassium permanganate in colorless or only faintly colored solutions. It does not work so well in the titration of the dichromate ion, as it is a weaker oxidant and the green color of the chromium chloride interferes. It is, however, perceptible, and with some degree of skill and experience may be used satisfactorily. It is best used when the lead chromate is filtered through a paper instead of an asbestos pad, as the latter helps obscure the end point.

The ferric chloride formed by oxidation has a tendency to interfere with the indicators, hence the addition of phosphoric acid which forms with the ferric ion a colorless, complex ferri-phosphate which does not interfere in any manner.

The phosphoric acid is prepared by mixing one volume of syrupy phosphoric acid with one volume of water.

Filtering and washing of the precipitate is the least satisfactory portion of the entire procedure. It is, naturally, absolutely essential that all precipitate be retained and all soluble chromates washed out. Satisfactory filtration may be obtained by the use of vacuum, a porcelain filter cone and the finest of filter papers. The porcelain filter cone is placed in the bottom of the funnel to prevent rupture of the paper by vacuum, which should be applied cautiously.

Fritted glass filters or Gooch crucibles with a thin layer of fine grade, long fiber asbestos in the bottom works very nicely by altering the procedure as follows: Scrape from the Gooch crucible, into the original beaker, the layer of asbestos and precipitated lead chromate. Hold the crucible over the beaker and dissolve any precipitate adhering to it by washing it with a stream of dilute HCl (20 to 30cc). Dilute to about 100cc. and proceed. The fine asbestos suspended in the titrated solution does not interfere seriously with the determination of the end point when sodium diphenylamine sulfonate is used as the indicator.

[1] Willard and Furman's book, Elementary Quantitative Analysis, page 179.

[2] The lead chloride does not precipitate. It remains in solution due to the high concentration of the chloride ion.

[3] Smith, in his book Quantitative Chemical Analysis, recommends the use of an acid, sodium chloride solution for this purpose. It is prepared by mixing 10cc. of concentrated HCl with 15cc. of water and diluting to 100cc. with a concentrated solution of sodium chloride. This mixture was not used in these experiments.

Recovery of By-Products

From the Doctor Cycle

KENNETH S. VALENTINE and
GORDON MacLEAN

Turbo-Mixer Corporation, New York

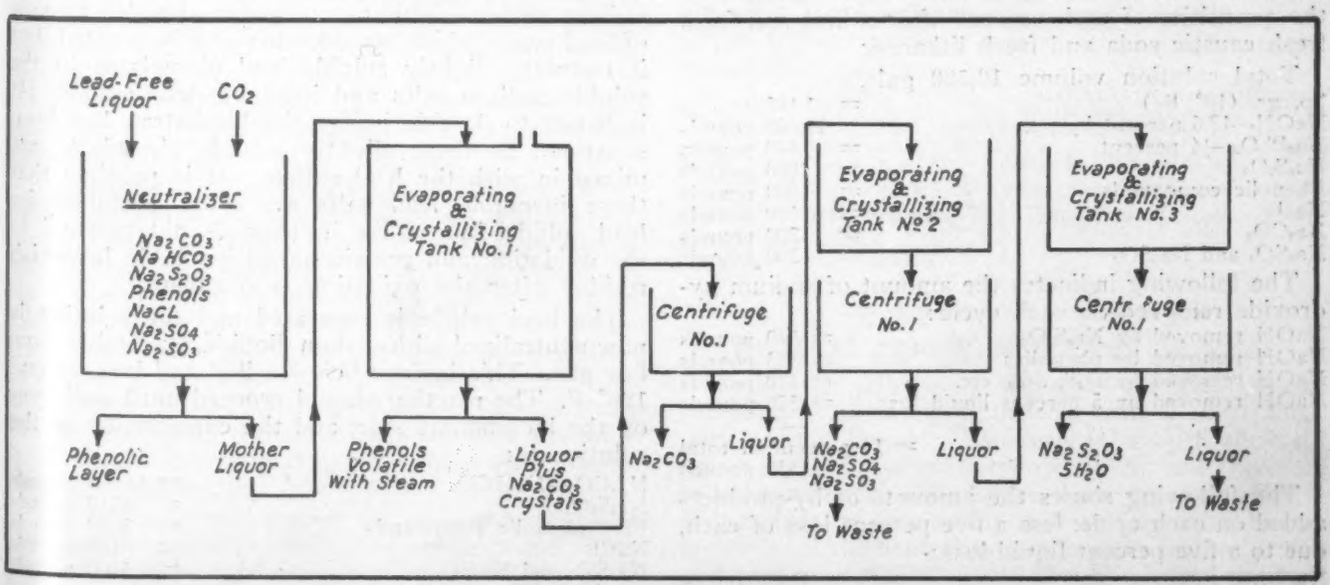
DOCTOR sweetening long has been considered a necessity. Recently this has been especially true because of the larger quantities of sour naphthas produced by modern cracking methods in the endeavor to gain a high yield of unsaturates. Many a refinery daily converts more than 10,000 pounds of lead sulfide back to litharge and sodium plumbite. If they did not make this recovery, the cost of doctor treating would be prohibitive. Many also use some of the alkalinity remaining in spent doctor for various neutralizations.

But no recovery process is complete if anything of value goes down the sewer. L. C. Trescott pointed out in his article "The Salvage of Refinery Waste" in the January, 1935, REFINER—"Mark this as a starter—any value recovered from waste is so much velvet." Therefore, considering the doctor cycle, what about the thiosulfate, the smaller quantities of sulfides, sulfites and sulfates? What about the phenolic compounds? What about a thoroughly satisfactory recovery of caustic?

From their experience in the manufacture of organic and inorganic chemicals the authors know that such questions arise constantly in these industries and must be answered to keep the business alive. In refinery practice the same problems turn up, but often they appear wearing a false face and a beard and we say. "Well, you're different! I can't do anything for you." However, if the chemical company can do something about it, so can the refinery—at a profit.

Previous articles by the authors in the January, 1935 and April, 1935, REFINER touched upon methods of separating black-strap completely from both naphtha and spent doctor layers, thereby making possible a nearly perfect separation of these layers. This, in turn, makes possible the recovery of practically all of the spent doctor solution. It is the prupose of this article to indicate ways in which everything of value may be recovered from this solution, some in the form of a pure product which may be marketed commercially and the rest in a form which may be consumed within the refinery.

Let us assume that we use for doctor treating a sodium plumbite solution, equivalent to 3½ percent litharge, with excess caustic soda to bring to 18° Be. After treating, the litharge content is one half of one percent. The separation of naphtha, spent doctor and black-strap is effected by modern methods and 95 percent of the lead sulfide, together with 95 percent of the spent doctor liquor is delivered to the oxidizer. The oxidation is complete. Then litharge amounting to five percent of the total quantity is added to bring the plumbite again to 3½ percent concentration. Also enough caustic soda is added to bring back our mixture to 18° Be. The general practice is to repeat the above cycle about seven to ten times before discarding the liquor



Flow sheet for Method 1 for recovery of by-products from spent doctor solution.

as worthless because the concentration of impurities such as thiosulfate has become so high that they crystallize out. Another practice is to bleed off a portion of the liquor, say one seventh, on every cycle, replacing this with an equal amount of fresh caustic liquor. Without going into the mathematics of this procedure, it is obvious that after the first few cycles, the impurities will always be present in quantities just below the saturation point. Therefore, the liquor which is drawn off in small portions will be of approximately the same composition as that which is discarded in one large portion every seven to ten batches.

It should be noted here that 18° Be. on a spindle only tells the truth about plumbite and caustic soda in the first cycle. In the second cycle, thiosulfate has been formed (and other compounds) which register specific gravity on the spindle, but not causticity. Furthermore, after the first cycle, a titration for alkalinity does not show the amount of caustic soda present because the phenolates and similar compounds are also strong alkalies and, to most indicators, have the same end point as caustic soda. It seems possible very often to have present so much of this false alkalinity that there is not enough true caustic soda content to permit the revivification or oxidation operation to proceed rapidly. This statement does not even take into account the tremendous oxidation-inhibiting effect of these phenolic compounds.

As there are many refineries recovering more than 3000 pounds of lead oxide per day, this amount has been chosen as a basis for calculation. Specifically, then, what is the composition of a typical discarded spent doctor solution? Which of the ingredients have value? How may they be recovered and in what quantity and quality?

The generally accepted equation for the oxidation of lead sulfide in the presence of caustic soda is

$$2\ PbS + 2O_2 + 6\ NaOH \rightarrow 2\ Na_2PbO_2 + Na_2S_2O_3 + 3\ H_2O$$

In this manner, thiosulfate is formed. Other compounds present are sodium plumbite (0.5%) the sodium and lead salts of phenolic compounds, sodium chloride and carbonate (from the caustic soda) and sulfates and sulfites from the acids which were neutralized. The following is fairly representative of the quantities of each present after a **first** run from fresh caustic soda and fresh litharge;

Total solution volume 10,500 gals.

Sp. gr. (18° Be)	= 1.142
NaOH—12.6 percent by wt.	= 11,000 pounds
Na_2PbO_2—½ percent	= 440 pounds
$Na_2S_2O_3$	= 1060 pounds
Phenolic compounds	= 1000 pounds
Nacl	= 110 pounds
Na_2CO_3	= 200 pounds
Na_2SO_4 and Na_2SO_3	= 200 pounds

The following indicates the amount of sodium hydroxide removed on each cycle:

NaOH removed by $Na_2S_2O_3$	= 540 pounds
NaOH removed by phenolics	= 333 pounds
NaOH removed by H_2S, SO_2, etc.	= 110 pounds
NaOH removed by 5 percent liquid loss	= 550 pounds
	= 14 percent of total 1533 pounds

The following shows the amounts of by-products added on each cycle, less a five percent loss of each, due to a five percent liquid loss:

$Na_2S_2O_3$	= 1010 pounds
Phenolates	= 950 pounds
NaCl	= 104 pounds
Na_2CO_3	= 190 pounds
Na_2SO_3 and Na_2SO_4	= 190 pounds
	2444 pounds

The average specific gravity of this mixture in solution at various concentrations is about half the gravity of sodium hydroxide at the same concentrations. It will then be seen that if we are taking away 1533 pounds of caustic soda, we should reduce the specific gravity of the 10,500 gallons from 1.142 to 1.122. But because we are at the same time adding 2440 pounds of a mixture as above, the gravity has actually only been reduced to 1.133. To restore the gravity to 18° Be. or 1.142 specific gravity we need only to add 690 pounds NaOH instead of the full 1533 pounds. Consequently, at the end of ten cycles it will be found that the actual caustic soda present in this spent doctor liquor is about half of the original amount.

The following shows the composition of a typical spent doctor solution, discarded at the end of ten cycles, allowing a five percent liquid loss, restoring the original volume of 10,500 gallons and bringing to 18° Be. with caustic soda on each cycle:

Na_2PbO_2(as PbO)	= 440 pounds
NaOH	= 5050 pounds
$Na_2S_2O_3$	= 8510 pounds
Phenolates	= 8020 pounds
NaCl	= 130 pounds
Na_2CO_3	= 240 pounds
Na_2SO_4 and Na_2SO_3	= 1600 pounds

The plumbite, the caustic, the thiosulfate and the phenolates have value, but are all of them recoverable? The answer is "Yes." However, the caustic can never be directly recovered as such, nor can more than 75-85 percent of the thiosulfate (depending on the process) be recovered in a pure form. The phenolates will be troublesome. Nevertheless, there are several hundred dollars worth of chemicals here and they are worth going after, provided the cost of getting them out is not too high. Three methods for accomplishing this recovery are now presented.

NEUTRALIZING WITH CARBON DIOXIDE

Method 1. In all cases, the lead must first be removed. This is done by precipitation, while the solution is hot, with either hydrogen sulfide or sodium sulfide. This not only recovers 440 pounds of lead oxide which would otherwise be wasted, but it converts slightly soluble lead phenolates to the soluble sodium salts and insoluble lead sulfide. It is better to do this before the blackstrap has been separated as these slightly soluble phenolates are mixed in with the lead sulfide. It is possible that these insoluble lead salts are often mistaken for lead sulfide, but unlike it, they do not respond to the oxidation and remain as an insoluble brownish residue after the oxidation is complete.

The lead sulfide is separated and the solution is now neutralized with carbon dioxide, preferably from flue gas. This is done below a boil and best around 120° F. The reaction should proceed until well over on the bicarbonate side, and the composition of the solution is:

Na_2CO_3—$NaHCO_3$	= 11,000 pounds
$Na_2S_2O_3$	= 8510 pounds
Free phenolic compounds	= 8020 pounds
NaCl	= 130 pounds
Na_2SO_4 and Na_2SO_3 in 10,500 gallons.	= 1600 pounds

The phenolic compounds are now separated. Nat-

urally, the exact nature of these will vary with each refinery's cracking process and with each crude. Phenol and cresol usually will predominate, but xylenol, mesitol, durenol, cyclohexanol, dihydroxy compounds, etc., probably also will be present, as well as small amounts of phenols with side chains. Some of them will undoubtedly separate as a layer which can be skimmed off. Most of these bodies are volatile with steam and those in solution may be thus separated from the mother liquor. In fact, the steam distillation may be carried out during the evaporation of the liquor for the next stage. The phenols may then be freed from water, purified and even separated from each other by subsequent fractional distillation in vacuo. An alternate method for separating these from the mother liquor is by solvent extraction, bringing the spent doctor liquor in contact with several successive portions of a solvent such as naphtha or benzol. This method might serve better than steam distillation when water-insoluble xylenols, mesitols or durenols are to be removed.

Many uses for these phenols can be found. A suggested use is for synthetic resins. Another suggested use is as a solvent in a lube purification process. Here is a chance for a cheap solvent, costing a refinery practically nothing and to be had in sufficient quantity to run a solvent process. A third possibility is the use of these compounds directly, or of their derivatives, as anti-oxidants in gasoline.

To recover carbonates, the solution is evaporated from 10,500 gallons to a point around 2000-2500 gallons. Sodium carbonate separates. After cooling to about 110° F. and centrifuging, a recovery of about 80 percent of the total, contaminated with some sulfate, sulfite and thiosulfate may be made. The cake is not washed. From this 9000 pounds of sodium carbonate, about 6800 pounds of sodium hydroxide may be recovered by causticizing with lime and returned to the process. Any sodium sulfite which crystallizes out with the sodium carbonate is also useful as it will causticize to the extent of about 50 percent with the lime.

It should be considered that the 2000 pounds of sodium carbonate as well as the sodium sulfate and sulfite remaining in the mother liquor are worthless. They are eliminated by further evaporation of the mother liquor, when they are "salted out" by the thiosulfate even at a boil. They are removed from the solution by centrifuging and the centrifuge cake is not washed.

To recover sodium thiosulfate, the liquor is further evaporated to about 1300-1500 gallons and cooled. Most of the thiosulfate now separates as the hydrate $Na_2S_2O_3$ $5H_2O$. This is centrifuged and the 300 or 400 gallons of mother liquor is discarded. The thiosulfate is in fairly pure form, but before it is marketable as "hypo" it must be dissolved, boiled with activated carbon to decolorize, filtered and recrystallized. As the size and form of crystals is very important, it should be noted that a suitably large crystal is obtained by extremely slow stirring during crystallization.

There is a definite market for sodium hyposulfide running up to thousands of tons per year and surely "hypo" made by this method could be offered at an attractive price. However, if every refinery were to recover all its hypo and attempt to sell it, the market would soon be flooded and broken—but there is little danger of this.

The necessary equipment is not elaborate and most of it is shown in the flow-sheet. The neutralizer is about 12 feet diameter by 15 feet high, and may be open top. The evaporating and crystallizing tank No. 1 is of the same size; but it is covered and is equipped with a condenser to condense the water-phenols mixture which is steam-distilled from this tank. (All phenols that were not previously skimmed off should be recovered in the first 500-1500 gallons of distillate, and a receiver of this capacity must be provided for the condensate). One centrifuge may be used for all operations. It should be of about one ton capacity. Two more evaporating and crystallizing tanks (Nos. 2 and 3) each about eight feet in diameter by eight feet high, will take care of all other evaporations and crystallizations. They may also be used for recrystallizing the thiosulfate. Besides this equipment, a vacuum still, with good fractionating column and condenser, must be provided for phenol purification. This must be capable of operating at 28 to 30 inches of vacuum and be jacketed for 100 pounds steam pressure. It need not be over 500 gallons capacity, as there is no need for running the entire ten days collection at once.

The neutralizer and the evaporating tank No. 1 should be equipped with good mixers, preferably the turbine type. Evaporating and crystallizing tanks Nos. 2 and 3 should also be equipped with mixers, but these should be of the very slow speed scraper type. The neutralizer and all tanks in which thiosulfate is evaporated must be of stainless steel in order to prevent serious contamination of product. For best results, the condenser on the vacuum still should be either of stainless steel or of nickel.

The entire cost of recovery is very small. The total processing cost for recovering either the caustic soda or the thiosulfate is not over three to five mills per pound, taking into consideration the chemicals used, steam, power and labor, whereas the market price of either of these materials is about 2½ cents per pound. The cost of recovering the phenols is not over one cent per pound, whereas they are probably worth ten times that amount.

The following seems a fair estimate of costs vs. values recovered:

COSTS		MATERIALS RECOVERED	
Materials		$NaOH$—6800 lbs. @ 2½c..	$170.00
CaO—5000 lbs. @ .5c.....	$25.00	$Na_2S_2O_3 \cdot 5H_2O$—9500 lbs. @ 2c	190.00
Activated Carbon	10.00	Phenols—7500 lbs @ 5c....	375.00
Steam			
100,000 lbs @ 30c.....	30.00	Total lbs., 23,800	
Power		Total value	$730.00
100 KWH @ 8c.....	8.00		
Total cost (except maintenance and depreciation)	$93.00		

Cost of recovery per pounds—4/10c

NEUTRALIZING WITH SULFUR DIOXIDE

Method 2. Having precipitated all lead as lead sulfide and removed it, the solution is neutralized with sulfur dioxide. The gas is a by-product of many reactions in refinery operation, and therefore in some refineries this can be the source of the SO_2. If it cannot be obtained in this way, a sulfur burner is used. This neutralization is done below a boil and best around 180° F. It should proceed until all alkalies present have been converted to sodium sulfite and the mixture is very slightly over on the

bisulfite side. Rosolic acid is the ideal indicator to determine the correct end-point of this reaction. Naturally, any carbonate present is also converted to sulfite, according to this equation:

$$Na_2CO_3+SO_2+H_2O \rightarrow Na_2SO_3+CO_2+H_2O$$

The phenolates are converted as follows:

$$2\ PhONa+H_2SO_3 \rightarrow 2\ PhOH+Na_2SO_3$$

The composition of the solution is:

Na_2SO_3	=	13,700 pounds
$Na_2S_2O_3$	=	8510 pounds
Phenols	=	8020 pounds
NaCl	=	130 pounds
Na_2SO_4	=	1000 pounds

in 10,500 gallons.

It will be found that the phenols separate in a better layer from this sulfite-thiosulfate solution than they did from the carbonate-thiosulfate mixture. This layer is now skimmed off. If a cone bottom tank is used for the neutralizing operation, it will serve as a good layer separator when the liquid is being drawn from the tank. The aqueous layer is now put in the evaporator, and, as in Method 1, the balance of the phenols is recovered by steam distillation during the evaporation.

The main feature of Method 2 is the addition of sulfur during the evaporation, and the conversion of all the sulfite to thiosulfate according to the following equation:

$$Na_2So_3+S \rightarrow Na_2S_2O_3$$

This is a quantitative reaction at a boil. Some excess (over theory) of flowers of sulfur should be used. The advantage of the method is that the composition of the solution is greatly simplified and there is now only thiosulfate to deal with in the presence of only small amounts of impurities.

$Na_2S_2O_3$	=	25,700 pounds
NaCl	=	130 pounds
Na_2SO_4	=	1500 pounds

After evaporating to about 4000 gallons, most of the sulfate and chloride is "salted out" and the batch is centrifuged while hot. Here the excess sulfur is also separated with the solids. The liquor now contains about 25,500 pounds of $Na_2S_2O_3$, or 38,300 pounds of $Na_2S_2O_3$-5 H_2O. On cooling with gentle stirring, the bulk of the $Na_2S_2O_3$-5 H_2O will crystallize out and is removed by centrifuging. About 32,000 pounds is obtained as a first fraction. The centrifugate may be further evaporated for a second fraction of about 2500 pounds and the liquor from this is discarded. The thiosulfate crystals are purified by recrystallization as in Method 1.

Another advantage of this method is that there is less evaporating to be done. On the other hand, there is a disadvantage in the fact that the thiosulfate produced by a refinery recovering 3000 pounds of litharge per day is around 1,000,000 pounds per year, a quantity which will at least be noticeable when it is marketed.

The equipment for this method is practically the same as for Method 1, except that the causticizing apparatus is eliminated. Lead has been found to stand up very well for handling sulfur dioxide and sulfurous acid and could be used for lines to the neutralizing tank. Since a mixer is to be used in this tank, it can be of the turbine type, which also has advantages for gas absorption. If the gas pressure is very low, i.e. a few ounces, a very effective method for absorption is to circulate the liquid through a filled stoneware column, about two feet six inches in diameter by 10 feet high, entering the gas at the bottom.

The following is an estimate of costs vs. values recovered:

COSTS		MATERIALS RECOVERED	
Materials		$Na_2S_2O_3$—35,000 lbs @ 2c.	$ 700.00
Activated carbon	$ 20.00	Phenols—7500 lbs. @ 5c..	375.00
Sulfur for SO_2...3100 lbs. for $Na_2S_2O_3$ ..5200 lbs.			
8300 lbs. @ 1c	83.00		
Steam 80,000 lbs. @ 30c.....	24.00		
Power 1000 KWH @ 8c.....	8.00		
Total cost (except maintenance and depreciation)	$135.00	Total lbs., 42,500. Total value	$1075.00

Cost of recovery per pound—32/100c

CAUSTIC TREAT BEFORE DOCTOR TREAT

Method 3. This is not only a method for handling the spent doctor liquor, but involves the entire treating cycle. Furthermore, the practice of caustic washing is nothing new, as it is now often done in refineries, especially when H_2S is high.

If the recovery of inorganic compounds from spent doctor solution is to be done at maximum efficiency, the preliminary removal of many organic products by caustic washing the naphthas between acid treat and doctor treat is highly desirable. By it, phenols and other compounds otherwise discoloring the spent doctor solution are removed and collected in one place, so that neither their lead nor their sodium salts can cause poor layer separation (of naphtha and doctor) or retard the oxidation of PbS. Furthermore, titrations of the doctor solution can now be relied upon to show the true amount of sodium hydroxide present, rather than hydroxides plus phenolates, and consequently the strength of the solution will be under more accurate control. Sodium sulfate, sulfite and sulfides are also present in varying amounts.

When good scrubbing action is a feature of the caustic treat, it will be found that the liquor may be recycled until all of the hydroxide has been utilized. Therefore, an additional advantage of this method is that the phenols are both freed and separated from a solution of around 2500 gallons concentration as compared to the 10,500 gallons under Methods 1 and 2. Thus a better partition of phenols and liquor takes place, with the result that a much smaller quantity of phenols is left in the aqueous layer to be removed by steam distillation or solvent extraction.

The manner in which this solution is handled depends on whether the phenol-free spent doctor solution itself is worked up generally according to Method 1 or Method 2. If carbon dioxide is to be used for neutralizing the main solution, it should also be used for neutralizing the phenolate solution. In this case, the liquor, containing the carbonate from this neutralizing may be used as the basis of the causticizing operation, and to it may be added the solid carbonate recovered from the main doctor liquor. On the other hand, if sulfur dioxide is used in both places, the two liquids, both containing sulfite, may be combined for the thiosulfate reaction, or, as a variant, the sulfite liquor from the phenols may be evaporated and cooled separately to produce a marketable sodium sulfite, Na_2SO_3-$7H_2O$, which sells for approximately the same price as thiosulfate.

Octane Number

Of Doctor Sweetened Naphtha

Improved by Rerunning

GEORGE M. WOODS

DURING a recent investigation on doctor sweetening East Texas crude naphtha by the sodium plumbite method it was observed that rerunning after sweetening improved the octane number about four points over rerunning followed by doctor sweetening. These results have been carefully checked and as the following discussion will show the octane number improvement is quite marked. The four point raise in octane number is worth 7/8c per gallon as 62.5 octane number gasoline is listed at 4¾c per gallon while 66.4 octane number gasoline is listed at 5⅝c per gallon. (September 19, 1935). A plant handling 10,000 barrels per day of crude naphtha could thus make $3,375.00 per day more by rerunning their doctor sweetening crude naphtha, on an octane number differential basis, over and above the cost of rerunning at 3c per barrel.

The properties of the 400°F. end point naphtha cut from East Texas crude is shown in Table 1 (column 1). A sample of this naphtha was divided into two equal portions. One portion was doctor sweetened in the customary manner by adding plumbite solution and sulfur and shaking until a break was obtained or until the sample tested sweet to the doctor test. This sweetened sample was water washed and rerun to 10 percent bottoms using steam and a maximum bottoms temperature of 330°F. The second portion (unsweetened) was rerun under exactly the same conditions as the sweetened sample, namely to 10 percent bottoms using steam and a maximum bottoms temperature of 330°F. This latter sample was then doctor sweetened with plumbite, sulfur, and shaking and given a water wash. Inspection of the two preceding overheads is given in Table 1 (columns 2 and 3). The rerunning loss on the two portions were 0.96 and 0.93 percent respectively for the sweetened before rerunning and the unsweetened before rerunning samples.

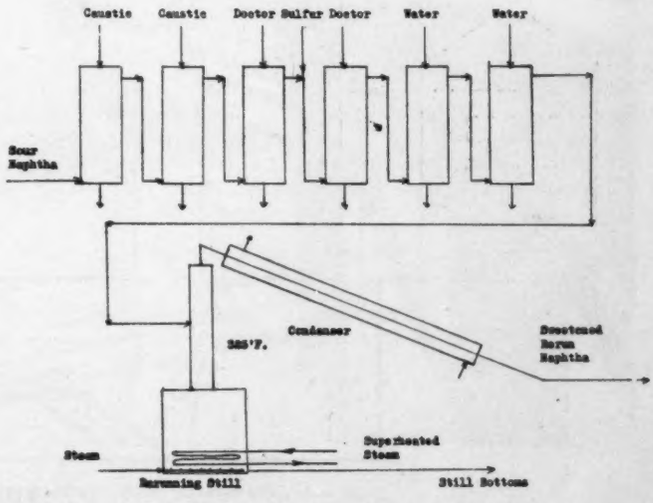
A study of the preceding data clearly shows the similarity of the overheads of the rerun samples in all properties except octane number ratings. The fills are approximately the same on both samples, and so the gain in octane number of 3.9 points must be attributed to the sweetening before rerunning operation.

A float sheet of a plumbite doctor sweetening and rerunning unit is shown in the accompanying diagram.

The effect of doctor sweetening naphthas from other crudes as well as cracked naphthas before and after rerunning are at present being investigated.

TABLE 1

PRODUCT	1 Sour East Texas Naphtha	2 Sweetened and Rerun to 10 Percent Bottoms	3 Rerun to 10 Percent Bottoms and Sweetened
Gravity, ° A.P.I.	58.0	58.5	58.5
I.B.P., ° F.	104	103	104
5%	146	147	147
10%	164	161	162
20%	186	181	183
30%	205	199	200
40%	226	218	218
50%	248	233	234
60%	267	253	253
70%	287	271	272
80%	307	292	292
90%	336	324	322
95%	360	348	349
F.B.P.	398	382	385
Recovery, Percent	98.0	98.0	98.0
Residue, Percent	0.5	0.5	0.5
Loss, Percent	1.5	1.5	1.5
Reid Vapor Pressure, Pounds per Square Inch	5.2	4.4	4.4
Octane Number, C.F.R.	61.3	66.4	62.5
Doctor Test	D.N.P.	O.K.	O.K.
Corrosion	O.K.	O.K.	O.K.
Sulfur, Percent	.038	.038	.039



FLOW SHEET OF DOCTOR SWEETENING AND RERUNNING UNIT.

Thermal *Polymerization of Gaseous Hydrocarbons*

POLYMERIZATION of gaseous hydrocarbons to produce liquid motor fuels is divided into two classes, namely, catalytic and thermal. For several years, both types of processing have been the subject of extensive research.

Until quite recently the gaseous hydrocarbons of the petroleum refining industry have been used primarily for fuel purposes in processing. However, in the past few years the results of research and commercial development have proven that these gaseous hydrocarbons may be used advantageously for the production of motor fuels of superior quality. In addition, it has been found that thermal polymerization is commercially practical for the treatment not only of gaseous hydrocarbons from refineries, but also of gases produced coincident with the production of crude petroleum.

The catalytic polymerization process, as the name implies, depends upon catalysts as an aid to the reaction, while thermal polymerization is accomplished by heat and pressure alone. With catalysis, the gaseous hydrocarbons susceptible to reaction are confined to the unsaturated type, while with the thermal process the material susceptible to reaction includes both the unsaturates and the saturates. This fact is important commercially, for the reason that both refinery and natural gas hydrocarbons consist essentially of the saturated type.

POLYMERIZATION PROCESS CORPORATION recently has offered to the refining and natural gas industries a process for thermal polymerization of all types of gaseous hydrocarbons. This process is the result of research and development on both catalytic and thermal investigations, and while the results of research indicate that both catalytic and thermal processes may be employed, the thermal process has been selected for presentation to the industry by reason of its application to all types of gaseous hydrocarbons, its higher yields of motor fuel per unit of charge, and its commercial application on a large scale.

Gaseous hydrocarbons normally produced from the refining or production of petroleum comprise essentially the following: hydrogen, methane, ethane, ethylene, propane, propylene, butane, butylene.

The charging stock to the polymerizing zone of

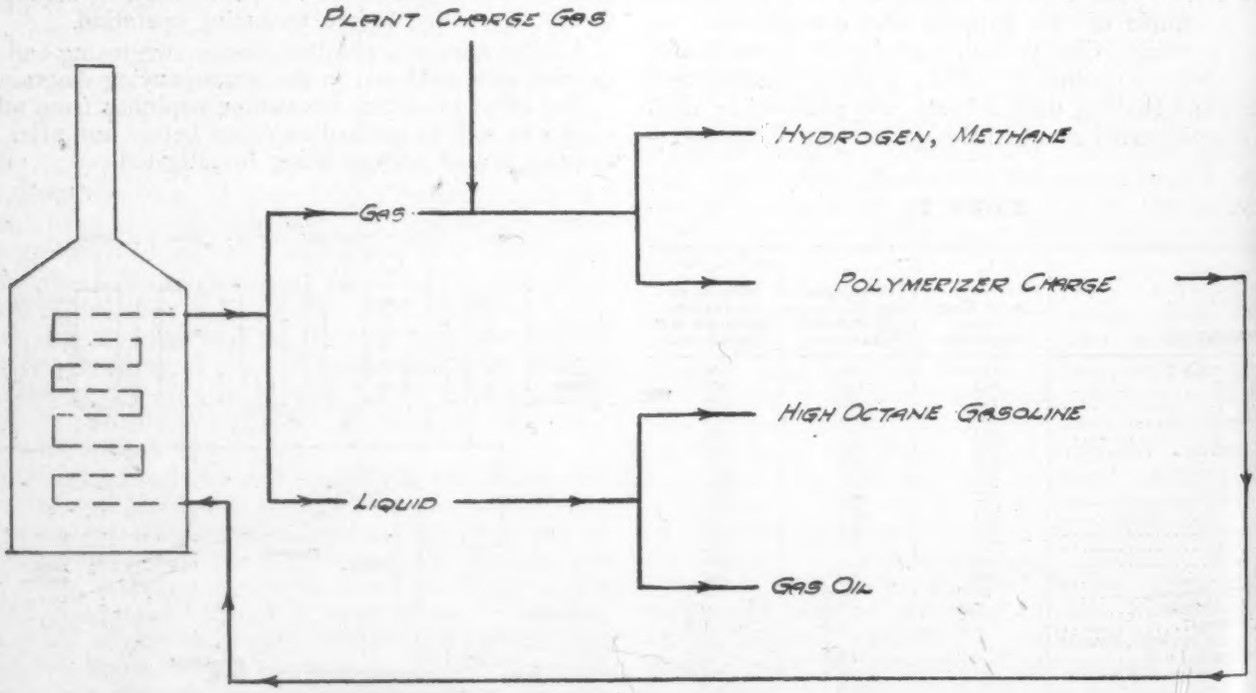
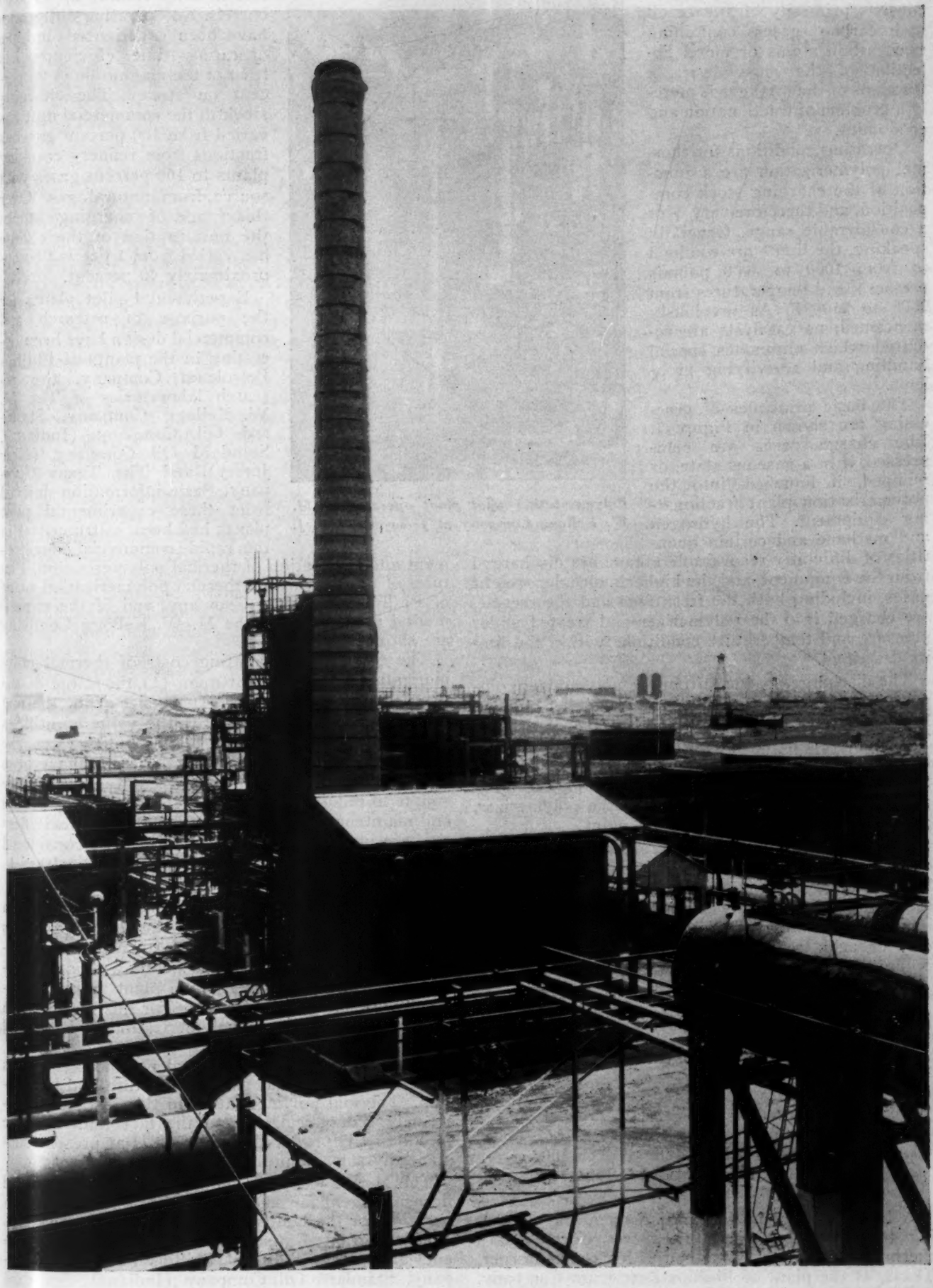


FIGURE 1
Thermal Polymerization Plant.

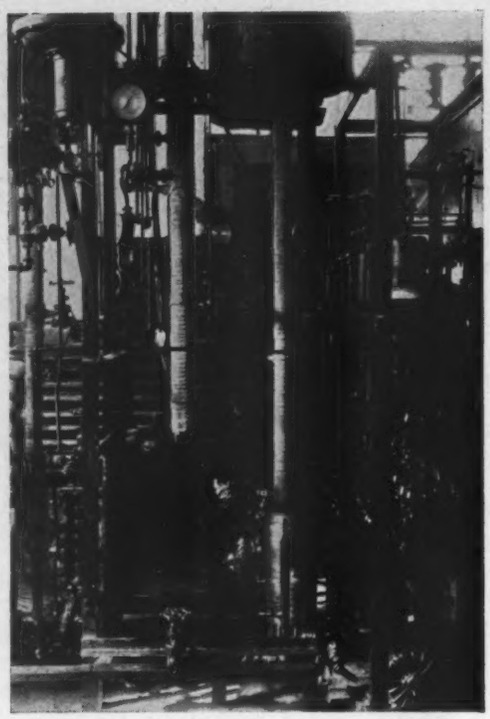


Phillips Petroleum Company's polymerization plant at Borger, Texas.

the thermal polymerization plant consists primarily of any or all hydrocarbon gases containing two carbon atoms or more. Selection of the most desirable fractions of the total gas is merely a problem of fractionation and economics.

Operating conditions for thermal polymerization are a function of the charging stock composition, and therefore vary over a considerable range. Generally speaking, the limits are confined to from 1000 to 3000 pounds pressure, and temperatures from 950° to 1100°F. As previously mentioned, no catalysts are required which eliminates special handling and revivifying problems.

The basic principles of processing are shown in Figure 1. The charge gases are compressed, if in a gaseous state, or pumped, if liquefied, into the polymerization plant fractionating equipment. The hydrogen and methane and certain quantities of difficultly recoverable ethane are discharged from the equipment, and the higher molecular weight gases, including both the fresh feed and the recycle are charged into the polymerizer and treated under pressure and temperature conditions within the limits described.



Polymerization pilot plant operated by M. W. Kellogg Company at Jersey City, N. J.

The discharge products from the polymerizer comprise hydrogen and methane, recycle (higher molecular weight gases), gasoline, and a trace of gas oil. This mixture, in combination with incoming fresh feed to the unit, is fractionated under pressure and the hydrogen and methane removed from the plant as fuel gas, the recycle returned to the polymerizer, and the gasoline distilled to end point.

The characteristics of the polymerized gasoline are of special interest for the following reasons: (1) the boiling range exhibits excellent volatility; (2) it is a stable product, highly saturated in nature; (3) it is not gum-forming, and is readily refined with light clay or acid treatment; and (4) the octane value is unusually high.

A typical inspection is as follows:

A. P. I. Gravity	60 to 64°
Initial Boiling Point	94° F.
20 Percent	140° F.
50 Percent	170° F.
90 Percent	330° F.
End Point	400° F.
Octane blending value with respect to Reference Fuel A	80 to over 100
Saturation (acid absorption) 80 to 86 percent insoluble.	

A large commercial installation operating according to The Polymerization Process Corporation's thermal polymerization method, is located at Borger, Texas, at the plant of Phillips Petroleum Company, and has been in successful commercial operation for a considerable period, producing polymerized gasoline in daily volume up to 1000 barrels. No operating difficulties have been experienced and the operating time efficiency has been of the magnitude of 95 percent on stream. The charging stock to the commercial unit has varied from 100 percent gaseous fractions from refinery cracking plants to 100 percent gases with source from natural gas. Over this range of charging stocks the unsaturation of the charge has varied from 1 percent to approximately 40 percent.

Experimental pilot plants for the purpose of research and commercial design have been operating in the plants of Phillips Petroleum Company, the research laboratories of The M. W. Kellogg Company, Standard Oil Company (Indiana), Standard Oil Company (New Jersey), and The Texas Company. Basic information derived from these experimental pilot plants has been instrumental in the rapid commercial development and application of thermal polymerization. Pictures of the commercial thermal polymerization plant of Phillips Petroleum Company, and of the experimental pilot plant of The M. W. Kellogg Company are shown.

The commercial operating costs of thermal polymerization are dependent upon (1) the value of the gases charged to the unit; (2) the size of the thermal polymerization plant; and (3) the value of utilities used. Even in localities of higher utility rates, the operating costs of thermal polymerization have been proven to be very low. The operation is sufficiently simple to require a minimum personnel for operation and maintenance. No catalyst handling or revivification are necessary, and the plant may be considered comparable in simplicity to that of a normal cracking and stabilization unit.

The investment cost of a thermal polymerization plant varies considerably with the local conditions of application. In cases where cracking or fractionating equipment are available within a refinery, certain parts of the polymerization plant may be combined with existing equipment. For this reason, each application of thermal polymerization is a special refinery or field study.

A large application of thermal polymerization lies in the field of natural gas manufacture and production. Thermal polymerization in this instance is extremely economical, due to the fact that valuable motor fuel is produced from what is at present substantially a waste product.

The M. W. Kellogg Company has been appointed licensing agent for The Polymerization Process Corporation for the United States and foreign countries. Licenses granted are under the polymerization patents and patent rights of Phillips Petroleum Company, Standard Oil Company (Indiana), Standard Oil Company (New Jersey), The Texas Company, and The M. W. Kellogg Company.

Motor Fuel Testing

C. L. CHAVIGNY

AN ELEMENTARY test performed on all liquid petroleum products is the determination of the A.P.I. gravity using a constant mass hydrometer. Petroleum distillates having gravities of about 50° A.P.I. or better are usually classed as gasolines. In past years when gasolines were predominately straight run, gravity was a key test, but today with cracking and blended fuels gravity has little bearing on the quality of gasoline. However, as gasolines are purchased on a volumetric basis by the consumer, with all other conditions the same, the potential power per gallon is greater in a low than in a high gravity gasoline[1].

The pre-eminent position occupied by hydrocarbon mixtures as fuels for spark ignition engines is due to their high thermal value and ready volatility. Thermal values of gasolines are constant and are seldom considered in specifications. However, differences in horsepower-hours per pound developed by different fuels under equal conditions and equal compression ratios, precluding detonation, must be ascribed to differences in the thermal values of the gasolines[2]. In considering volatility requirements of gasolines the expected atmospheric temperatures at the time of use must be kept in mind. The points on an ASTM distillation curve often differ from the true boiling points because of the rough fractionation obtained, but owing to the careful standardization it gives an important evaluation of the volatility. The ASTM distillation data[1] has been definitely correlated with more absolute data. By graphical methods the percentages of butanes and lighter, pentanes, hexanes and heptanes and heavier, the Reid vapor pressures and temperatures of incipient vapor lock of gasolines have been calculated using their distillation curves[3]. Certain points in the ASTM distillation data have been singled out as being indicative of expected performance of the fuel.

The initial boiling point is governed by the percentage of very light ends in the gasoline but as they are such a small portion of the total quantity of fuel it has little significance. When making a cold start the quantity of fuel drawn into the cylinders is dependent upon the percentage of readily volatile fractions in the gasoline. The 10 percent point is considered an index of ease of starting. As no heat is derived from the engine on starting, the atmospheric temperature is very important in fixing the 10 percent point. In warming-up, heat from the motor aids in vaporization of the fuel, making the heavier fractions available. The rapidity of warming-up is dependent upon the 35 percent point. Once a motor is warm there is little difficulty experienced in vaporizing the fuel except in extreme cases. The boiling point of the major portion of the fuel is established by the 50 to 60 percent points and it is this major portion that provides rapid acceleration and good mileage in sustained driving.

In the upper end of the distillation curve the tendency of the fuel toward oil dilution can be predicted by a consideration of the 90 percent point. Oil dilution is appreciably affected by atmospheric temperature under conditions of steady operation. The end point is fixed by the percentage of heavy ends but its value is subject to the same criticism as the initial boiling point. Specifications on loss provide a check against the incorporation of excess quantities of very light material. The percentage of residue and end point limit the amount of heavy ends in the fuel. In the fuel of optimum boiling range for a specified atmospheric temperature excellent performance in one operation should not be obtained by sacrificing performance in other respects.

In the ASTM distillation the gasoline is roughly fractionated and the boiling points of the various fractions are determined. It is valuable to know the boiling point of a gasoline as a whole to determine the temperature of complete vaporization. In eight-, twelve- and sixteen-cylinder engines the distribution of fuel to the cylinders is more equal with a readily volatile fuel than with a heavier fuel. When the majority of the fuel is readily vaporized at the temperature of operation the motor gives a quick response on rapid acceleration. Also with a more volatile fuel a cooler mixture can be fed to the cylinders.

The theoretical approach to the total or effective volatility is through a consideration of the dew point, the temperature at which gasoline first condenses out of a definite mixture of air and gasoline vapors. The dew point is determined by direct experimental means. However, in recent investigations the effective volatility has been determined from a consideration of the ASTM distillation data. The average boiling point and certain critical points such as the 50 percent[4] and the temperature equal to one-half the 90 percent point have been proposed to give a numerical value to the effective volatility. When effective volatility is expressed numerically it is essential that the method of determination be known because the different methods do not give like figures. The effective volatility is elusive and it is difficult to reduce it to a comparative numerical basis. An examination of the total distillation curves with particular attention to the 30 to 70 percent received range is of value in getting an idea of the comparative total volatilities of two samples.

VAPOR PRESSURE

The Reid vapor pressure[1] is a measure of the amount of very light material in gasoline and indicates the ease with which gas will be formed in the fuel system, causing vapor lock. Reid vapor pressure specifications are entirely governed by the expected atmospheric temperatures. With increased

cooling of automobile fuel systems through better design, maximum allowable Reid vapor pressures are being raised, permitting use of more lighter fractions. The test is sbject to criticism in predicting the temperatures of incipient vapor lock because the volumes of gas liberated by samples of equal Reid vapor pressures are not always equal at all temperatures. In routine testing an accurate determination of the fractions lighter than hexane is not important but it is of particular importance to the refiner as a check on the efficiency of stabilization. With a definite maximum allowable vapor pressure it is to his interest to free the gasoline of high vapor pressure components, particularly propane, allowing the inclusion of more of the heavier fractions and increasing the gallons of gasoline per barrel of crude.

COLOR

The color of white gasolines gives some indication of the degree of refining but color has no direct bearing on the suitability of gasoline as a fuel. Saybolt color[1] is included in the specifications for white gasolines to insure a pleasing looking product. In both white and dyed gasolines color stability, the permanence of the color when the gasoline is exposed to actinic light, is of importance. When exposed to actinic light unstable gasolines undergo photochemical reactions producing a haze and/or a distinct color, both of which lower the Saybolt color. Haze, caused by suspended particles, can be removed by filtering usually with a restoration of original color. The formation of definite color is produced by dissolved matter and is usually permanent. To determine the color stability gasolines are exposed to sunlight for a definite period and then examined for haze and drop in color. If the development of haze is of prime importance the samples are exposed and examined periodically until the haze is produced. As the intensity of solar radiation varies daily, the comparative value of such tests is subject to criticism unless they are run simultaneously. Actinometers, usually involving light sensitive salts[5] reduce these tests to a comparative basis. This difficulty is eliminated when carbon arc lamps duplicating solar radiation are used in color stability tests.

GUM

Gum in gasoline forms varnish-like deposits in tanks and feed lines and on valves of gasoline engines. If these deposits are heavy enough they hinder or stop operation of the engine. It is the general opinion that under ordinary conditions ten to fifteen miligrams of gum per hundred cubic centimeters of gasoline should not cause trouble in an engine. Two notations are used to clearly specify the condition of the gum in gasoline. Actual or preformed is the gum existing in gasoline at the time of consideration. The potential is the gum formed by oxidation of the unstable constituents. When the potential gum is oxidized it is no different from preformed gum. Tests for determination of preformed gum strive to attain a very rapid evaporation under constant conditions with a minimum of oxidation. Preformed gum is sometimes determined by evaporating the sample at an elevated temperature in a porcelain dish under a current of air. Results obtained by this method are difficult to reproduce because of variation in operating conditions. This and other tests for preformed gum have given way to the ASTM method[1]. With conditions of operation constant and oxidation reduced to a minimum, the results obtained are highly reproducible and consistent with actual gum deposits in engines. In the copper dish test gasoline is evaporated under oxidizing conditions. Slow evaporation at an elevated temperature, the ready supply of oxygen and the catalytic effect of the copper all promote oxidation of the sample. The interpretation of copper dish data becomes difficult because the gum represents the preformed gum plus an undetermined quantity of the most easily oxidized portion of the potential gum. Results are variable because of variations in operating conditions.

Improperly refined gasolines are liable to form gum in storage. Determination of storage stability is approached through a correlation of actual storage stability and accelerated aging tests. The question of importance is how long can a gasoline be stored before preformed gum reaches an excess. Potential gum has no ill effects on the operation of an engine. Nearly all accelerated aging tests subject the sample to oxygen under pressure and at an elevated temperature.

The most common form of apparatus consists of a metallic bomb enclosed in a steam jacket with a recording pressure gauge connected to the bomb. In the usual test oxidation is negligible for a variable period, at the end of which time the oxidation becomes very rapid with a resulting drop in pressure. The induction period is the time elapsed between starting the test and the sudden drop of oxygen pressure. With some gasolines the drop in pressure is gradual and in these cases the induction period is considered terminated when the pressure drops a specified amount. The sample is left in the bomb a fixed time and then the gum content is determined. This gum, minus the preformed gum, is called the potential gum. The procedures used in accelerated aging tests are subject to limitations.

Ramsay and Davis[6] have shown that a considerable and variable time lapses before the sample reaches the fixed temperature. Also there is a slight superheating toward the end of the test and a variation in the rate of cooling the bomb after the steam is cut off. This last affects the potential gum. They suggest corrections to calculate the true induction period from the observed induction period. In some types of apparatus agitation eliminates the initial temperature lag. A serious objection to accelerated aging tests is that they are run at temperatures higher than those of normal storage. As the storage stabilities of gasolines vary at different temperatures, the induction period at 212° F. might be misleading in predicting the storage stability at normal temperatures. Induction periods at ordinary storage temperatures can be obtained by plotting the induction period at an elevated temperature versus the logarithm of the absolute temperature, or by extrapolating the induction periods at two or more different temperatures[7]. When the apparatus is provided with a manometer for the measurement of pressure the approach to the induction period is slightly different. The change in pressure can be read accurately and in one method[8] the induction period is considered terminated when the rate of absorption of the oxygen reaches one cubic centimeter per minute.

If the samples being tested have equal induction periods, differences in storage stability may be predicted by a consideration of the amount of oxygen

absorbed at the end of the induction period. Thus the method in accelerated aging tests resolves itself into a determination of the induction period and using the quantity of oxygen absorbed, the copper dish gum and the potential gum for more complete information. As storage conditions and the gasolines themselves differ greatly, the general correlation of accelerated aging test data with actual storage stability is difficult. However, Rogers, Bussies and Ward in a series of correlation tests concluded that a gasoline having an induction period of 400 minutes will be stable under ordinary storage conditions (Chicago district) for a year[8]. An induction period of three to four hours ordinarily indicates a stable gasoline without specifying any time of storage stability.

SULFUR

Excessive quantities of sulfur are undesirable in motor fuels because acids are formed and cause serious corrosion, particularly in bearings of the crankshaft and in the exhaust system when the car is subjected to repeated cold starts. The exact limit has not been established, but gasolines of 0.25 percent sulfur have been in general use in California for over five years, hence this is probably a safe limit. In the ASTM lamp method for determination of sulfur, all the sulfur, regardless of its combined form, is burned, giving a determination of total sulfur. The weaknesses of the method lie in the difficulties in burning the sample, the variability and probable impurity of the air supply and the difficulty in titrating to an end-point under conditions of the test[9]. The results are, however, highly reproducible.

The doctor test gives a positive reaction in the presence of mercaptans and hydrogen sulfide. A rapid formation of a black precipitate on addition of doctor solution shows hydrogen sulfide. It can be confirmed by a characteristic yellow precipitate produced with a cadmium salt. The lead mercaptides formed from the higher mercaptans on addition of doctor solution are oil soluble and color the oil layer yellow to brown while the lighter mercaptans form a yellow to brown precipitate. Black lead sulfide will be slowly formed if elemental sulfur is present in the gasoline. The test is completed by adding elemental sulfur. When positive, a rapidly darkening precipitate is formed.

A positive copper strip corrosion test[1] shows the presence of acids and/or certain forms of surfur. Acids are seldom present in gasolines. Small amounts of mercaptans and of elemental sulfur alone in gasolines are not corrosive but very small quantities of elemental sulfur in the presence of mercaptans are corrosive. Other sulfur compounds are not corrosive or only very mildly so[10].

DETONATION

Certain gasolines detonate violently in high compression engines with an accompanying loss of power and physical strain on the engine. The tendency of gasolines to knock in internal combustion engines is primarily a question of chemical composition. Gasolines from the same or similar crudes have detonation characteristics that vary as the boiling range. When knocking characteristics of fuels were first considered they were rated according to their aniline cloud points. At present detonation characteristics are determined not by chemical means but by an observation of performance in a special spark ignition engine under definite conditions and the gasolines are rated in octane numbers. In determining octane numbers the test fuel is bracketed between blends of standard fuels and the octane number is that percentage of iso-octane in a blend of iso-octane and normal heptane which would have detonation characteristics identical with those of the test fuel. The octane number of a gasoline is not an absolute value but is dependent upon the conditions of the test.

The ultimate aim of octane number testing is to determine how the gasoline will perform in the consumer's car as regards detonation. An exhaustive series of tests has been made to correlate the C.F.R.[1] results with actual operation[11]. In road runs test gasolines were rated in percentages of one standard fuel in the other by an observation of the knock intensities of the test and standard fuels under varying driving conditions and in different cars. The fuels were said to match when the maximum obtainable knock intensities were equal. The cars were operated at full throttle on varying grades and the speeds at which maximum knock occurred were not taken into consideration. The motorist is interested in how badly the fuel knocks and not at what speed it knocks. Having rated the test gasolines under conditions of actual operation they were then rated according to the then existing method for the C.F.R. engine. Correlation was imperfect so the variables of operation, speed, mixture temperature, throttle opening, timing and jacket temperature were varied until the knock ratings determined with the C.F.R. engine agreed with the road ratings. A slight change in valve design was also made. The revised method was called the motor method while the original method is referred to as the research method. The motor method has been adopted as standard by the American Society for Testing Materials.

It is recognized that when a cool air-fuel mixture is fed to the cylinders, a higher compression ratio may be used without detonation than when the mixture is fed at a higher temperature. Also increasing the compression ratio increases the power developed per unit of fuel if there is no detonation. The minimum fuel mixture temperature is limited by total volatility and the maximum compression ratio is limited by octane number. Brown and Marshall[12] have pointed out that the total volatility and the octane number are potential values to the extent that cars must be properly designed to take full advantage of these properties. The octane numbers of standard gasolines are uniform and motors are designed to take advantage of high octane fuels. It is very desirable, however, from the standpoint of conservation of natural resources, that cars should be able to operate satisfactorily on gasolines of greater front-end volatility.

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Relationship Between the Physical Properties *and* Chemical Constitution *of* Lubricating Oils

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WHEN one desires to compare the properties of various mineral lubricating oils, it is evident that the oils to be investigated possess the same viscosity at some arbitrary temperature such as 50°C., or 100°C. This method of grouping is employed since viscosity is one of the most important properties, according to which lubricating oils are manufactured and sold, and secondly, for the purpose of an arbitrary method of classification, this method is simple and it serves its purpose.

Selected samples of oils, used by the author in an earlier investigation,[5] and in the present work were therefore, divided into three classes. Oils within each class or group are of practically the same viscosity at 50°C., and the groups show the following limits:

Group A: Visc. of 4.1 to 4.6 deg. Engler.
Group B: Visc. of 10.9 to 11.5 deg. Engler.
Group C: Visc. of 21.9 to 22.9 deg. Engler.

All of the samples investigated are refined lubricants.

The physical characteristics of oils in the individual groups then were classified, as in Table I, according to their increasing specific gravity, so that at the top of the table are found the lightest gravity Pennsylvania oils of "paraffinic character," followed next by the "mixed-base" oils, and as the "naphthenic character" increases there finally follow the oils of the heaviest specific gravity or those of so-called "asphalt-base" such as the Roumanian oils.

Table I shows the results of the analyses of these oils: column 1 the viscosity in degrees Engler at 50°C, column No. 2, the specific gravity at 20°C, column No. 3, the pour point according to German Standard Testing Methods,[1] column No. 4, the absolute viscosity in centipoises made by the Voge-Ossag Viscosimeter determined at 30, 50, 100 and 200°C, column No. 5, the specific gravity-viscosity constant of Hill and Coates,[2] column No. 6, the viscosity-index of Dean and Davis,[3] column No. 7, the average boiling point and boiling point of the 90 percent cut, based on the boiling point curve from a fractional distillation made at 0.1 mm pressure, column No. 8, the Conradson carbon value,[4] and finally column No. 9, the amount of sludge formed during the oxidation, when passing oxygen through the oil for ten hours at 200°C. This test was conducted in a special apparatus using 60 cubic centimeters of oil in each case. Most of the results shown in Tables I and II have been more fully described by the author in a previous investigation.[5]

According to the above method of presenting the analytical data, it is seen that only those oils are compared which have the same viscosity at 50°C., and that the specific gravity seems to be an indication of certain trends of other properties of these oils. One notes that in Table I, column 4, the viscosity-temperature curve becomes regularly steeper as the specific gravity increases, and also that the absolute viscosity at 200°C,

[1]Standard Methods, German VI Ed., 1933, p. 98.
[2]Indust. Eng. Chem. 20, 641, 1928; Indust. Eng. Chem. Anal. Ed. 3, 144, 1931.
[3]Chem. Metall. Enf. 36, 618, 1929; S.A.E. Jour., 29, 247, 1931; Oil & Gas Jour., 30, No. 46, 93, 1932.
[4]A.S.T.M. Standards on Pet. Products, 1934 Ed. page 49.
[5]Petroleum 29, No. 40, 1-14; No. 41, 1-13 (1933).

TABLE I

Group	Sample No.	Visc. 50° C. Deg. Eng.	Sp. Gr. 20° C.	Pour ° C.	Viscosity in Centipoises, at deg. Cent. 30°	50°	100°	200°	Sp. Gr. Visc.-Const.	Visc.-Ind.	Boiling Point at 0.1 mm Hg., 0 deg. Cent. 90% Dist.	Average	Conradson Carbon (%)	Oxidation (Percent Sludge)
		1.	2.	3.	4.				5.	6.	7.		8.	9.
A.	C- 34	4.08	0.875	− 3	64.6	25.7	5.68	1.77 } At	0.814	76 ?	...	...	0.32	....
	C- 35	4.19	0.902	8	75.3	27.5	5.51	1.72 } 170°	0.851	32	...	...	0.11	....
	C- 33	4.56	0.932	−10	99.3	31.3	5.42	1.60 } C.	0.892	−65	...	...	0.16	....
B.	S- 29	11.15	0.881	0	206.0	69.4	11.85	2.00	0.807	100	390	287	0.94	0.50
	S-111	11.46	0.890	− 2	222.0	72.8	11.68	2.06	0.817	99	314	256	1.00	0.78
	S- 32	11.32	0.902	− 5	237.2	71.7	10.62	1.84	0.835	86	343	261	1.14	2.25
	D- 4	10.90	0.931	− 2	317.4	73.8	9.71	1.60	0.876	5	268	234	0.20	...
	S- 20	10.96	0.938	−13	257.4	73.2	8.99	1.60	0.888	17	278	233	0.44	5.17
C.	S- 28	22.65	0.886	0	481.0	144.4	19.65	2.93	0.804	103	390	328	1.71	0.69
	S-100	22.90	0.888	− 8	485.0	145.0	19.80	2.84	0.806	103	372	309	1.37	0.00
	S- 62	22.60	0.892	− 8	477.0	141.0	19.14	2.56	0.812	100	390	321	1.37	0.00
	S- 5	22.08	0.910	− 4	564.2	150.6	17.34	2.26	0.837	75	368	289	1.02	2.34
	S- 96	21.01	0.913	− 7	558.0	139.6	16.10	2.30	0.842	63	326	276	1.31	3.33
	S- 51	22.85	0.914	− 5	539.0	140.0	16.95	2.15	0.844	59	355	274	1.05	3.80
	S-115	22.44	0.934	1	701.4	148.7	15.44	2.05	0.872	33	314	254	0,78	9.33
	S- 40	22.60	0.935	− 8	726.0	154.5	15.56	1.96	0.875	7	285	260	0,55	7.77
	P- 4	22.53	0.947	−11	780.0	158.5	14.56	1.85	0.890	22	280	244	0.43	....

TABLE II

Group	Sample No.	Origin and Composition of Sample	Visc. 50° C. Deg. Eng.	Sp. Gr. 20° C.	Pour Point 0° C.	Absolute Viscosity Centipoises, at Deg. Cent. 30°	50°	100°	200°	Sp. Gr.-Visc. Constant	Viscosity Index	Conradson Carbon (%)	Oxidation Test (Percent Sludge)
			1.	2.	3.	4.				5.	6.	7.	8.
A.	C-35	Grosny.....	4.19	0.902	8	75.3	27.5	5.51	1.72 (At 170° C.)	0.851	32	0.11	7.6
	C-36	Mixture of 47% Roum. (4.6 E. & 0.932) with 53% Penn. (4.1 E. 0.875).....	4.22	0.902	− 6	75.8	27.2	5.56	1.69 (At 170° C.)	0.851	32	0.23	6.8
B.	S-51	Mid-Cont.....	22.85	0.914	− 5	539.0	140.0	16.95	2.15	0.844	59	1.05	...
	D- 2	Mix. of 56% Russ. (22.6 E. 0.935) with 44% Penn. (22.7 E. & 0.886).....	22.16	0.915	− 4	595.8	147.6	16.84	2.25	0.844	58	1.20	...
C.	D- 4	Balach. close cut.	10.90	0.931	− 2	317.4	73.8	9.71	1.60	0.876	5	0.20	...
	P- 6	Mix. of 72% Roum. (6.7 E. 0.934) with 28% Br. St. (57 E. 0.910).....	11.06	0.931	−19	310.0	73.8	10.19	1.60	0.876	20	0.66	...
D.	P- 4	Roum. Refined...	22.53	0.947	−11	780.0	158.5	14.65	1.85	0.890	22	0.43	...
	P- 5	Roum. Unrefined.	22.31	0.947	10	971.0	158.8	14.09	1.87	0.890	8	1.45	...

becomes increasingly smaller. The specific gravity-viscosity constants (column 5) calculated from the viscosity curve, the viscosity-index (column 6) and many other similar constants show also a trend in one direction or another. It is apparent that if one desires to characterize an oil as to its viscosity-temperature behavior, such as between 50 and 200°C., it is necessary also to state the specific gravity and to determine the viscosity at some temperature as 50°C. as well. At lower temperatures, such as those in the neighborhood of the pour point the separation of paraffin materially alters the determination of viscosity; the pour-point of the oil is a very important factor to be considered in all viscosity determinations.

Again it must be pointed out that additions of small amounts of synthetic oils or other preparations to straight mineral oils may seriously affect the viscosity or the index of the oil; in other cases where the pour-point is favorably depressed by adding extraneous preparations, the chemical constants again may be materially affected. The present investigation does not comprise mineral lurbicating oils which contain foreign ingredients or synthetic preparations of a.y kind.

The results of the fractional distillation at 0.1 mm pressure, shown in Table I, are worthy of note. It is seen that oils of low specific gravity (high A.P.I.) are considerably higher boiling, than those following which are heavier in gravity. The boiling-point of the 90 percent distillate for the Pennsylvania oils is for instance practically 100°C above that of the Roumanian oils, when comparing oils of similar viscosity at 50°C. The Conradson carbon value also shows a relation to the above properties. One notes that in this method of determination coking values, the more volatile oils, that is, those of a higher specific gravity, show in general a lower Conradson carbon value, as can be seen in Table 1, provided the oils under comparison are known to have been prepared or refined by similar methods. In column 9 the oxidation test shows that the light gravity (low specific gravity) Pennsylvania oils are the most stable as to sludge formation, and it can be said that sludge formation increases with an increase in specific gravity or the "naphthenic" (asphaltic) characteristics of the oil. One must, however, not fail to consider that the Conradson value, the oxidation test and similar type of tests are not only indicative of the true chemical nature of the oil in question (as is already indicated by the specific gravity) but that the presence of asphalts, asphaltic-coloring compounds, etc., also enter the picture; such substances can behave in the above tests as catalysts or even inhibitors of oxidation; furthermore, the above tests are greatly affected by the presence of added chemical synthetic compounds, a practice well established in the case of automotive fuels.

Since specific gravity is characteristic of the many properties of oils of equal viscosities, it follows that blends or mixtures of similar viscosity and gravity will again show a similarity in their physical-chemical constants; such similarities are, moreover, not influenced by the origin of the oil or its chemical make-up or even by the fact it may be composed of a narrow cut, or composed of blends of residual lube oils. That this is evident for oils containing no foreign admixtures or preparations, at least as far as viscosity-temperature curves is concerned (higher temperature ranges), is borne out in Table II.

Group A oils, Table II, comprise first a Grosny oil and also a mixture of Roumanian and Pennsylvania straight-run lube; group B, a Mid-Continent oil and for comparison a mixture of Russian and Pennsylvania oils; group C, a specially close-cut Balachany lube oil and with it a mixture of a light Roumanian lube cut with American bright stock; group D, shows a refined oil compared with an unrefined stock. One will note that the viscosity-temperature curve, and in general the derived constants are practically alike for each group. The agreement in the absolute viscosity at 200°C. (also 170°C.) is especially noteworthy. The agreement in Conradson carbon values and also the oxidation values for sludge is as close as can be practically expected, especially for such widely divergent oils as in group D, comprising products containing different amounts of asphaltic coloring matter.

The relationship between specific gravity, boiling points and the viscosity-temperature curve becomes clear for oils that are pure petroleum derivatives. These relationships, which have been previously described to some extent by other workers[6] are of course those

[6] Blackwood & Rickless: S.A.E. Journ. 28, 136, 1931. Mougey: S.A.E. Journ. 29, 200, 1931. Ehlers: Petroleum, 28, No. 41, 8, 1932. McCluer & Fenske: Jour. Ind. Eng. Chem. 24, 1371, 1932. Larson & Schwaderer: Nat'l Pet. News, 25, No. 9, P. 25-28, 1933.

TABLE III

Group	Sample No.	Vis. 50° C. Deg. E.	Sp. Gr. 20° C.	Aniline Point Deg. C. Before	Aniline Point Deg. C. After	Removal of Aromatic Hydrocarbons	Depression	Percent Aromatics	Apparent Mol. Wt.	Ultimate Analysis, Percent C	H	S	Ash	On Basis of Pure C H Hydrocarbon: Ultimate Analysis C	H	Apparent Formula	Apparent General Series
		1	2	3				4	5	6				7		8	9
A.	C- 34	4.08	0.875	104.9	111.0	6.1		16.8	438	86.34	13.31	0.11	0.00	86.64	13.36	$C_{31.6}H_{58.5}$	C_nH_{2n}— 4.7
	C- 35	4.19	0.902	91.1	104.8	13.7		33.7	399	87.26	12.48	0.17	0.07	87.49	12.51	$C_{29.1}H_{49.9}$	C_nH_{2n}— 8.3
	C- 33	4.56	0.932	71.0	93.3	22.3		48.4	369	87.33	12.05	0.27	0.11	87.87	12.13	$C_{27.0}H_{44.8}$	C_nH_{2n}— 9.2
B.	S- 29	11.15	0.881	120.3	124.9	4.6		12.9	609	86.63	13.26	0.09	0.03	86.73	13.27	$C_{44.0}H_{80.8}$	C_nH_{2n}— 7.2
	S-111	11.46	0.890	114.0	120.7	6.7		18.2	517	86.77	13.04	0.09	0.06	86.94	13.06	$C_{37.4}H_{67.5}$	C_nH_{2n}— 7.3
	S- 32	11.32	0.902	103.8	115.5	11.7		30.0	494	86.94	12.70	0.23	0.10	87.25	12.75	$C_{35.9}H_{63.0}$	C_nH_{2n}— 8.8
	D- 4	10.90	0.931	84.3	99.4	15.1		36.4	413	87.44	12.23	0.26	0.07	87.73	12.27	$C_{30.2}H_{50.7}$	C_nH_{2n}— 9.7
	S- 20	10.96	0.938	78.6	101.0	22.4		48.6	395	86.90	11.96	0.21	0.02	87.90	12.10	$C_{28.9}H_{47.9}$	C_nH_{2n}— 9.9
C.	S- 28	22.65	0.886	126.2	136.0	9.8		26.6	738	86.50	13.38	0.05	0.00	86.60	13.40	$C_{53.3}H_{98.8}$	C_nH_{2n}— 7.8
	S-100	22.90	0.888	125.4	133.5	8.1		22.0	722	86.56	13.53	0.04	0.06	86.48	13.52	$C_{52.0}H_{97.6}$	C_nH_{2n}— 6.4
	S- 62	22.60	0.892	125.2	133.0	7.8		21.5	649	86.78	13.29	0.05	0.04	86.72	13.28	$C_{46.9}H_{86.1}$	C_nH_{2n}— 7.7
	S- 5	22.08	0.910	109.1	120.2	11.1		28.7	553	86.88	12.77	0.32	0.00	87.19	12.81	$C_{40.2}H_{70.8}$	C_nH_{2n}— 9.4
	S- 96	21.91	0.913	106.7	118.4	11.7		29.8	531	87.14	12.90	0.22	0.00	87.11	12.89	$C_{38.6}H_{68.4}$	C_nH_{2n}— 8.8
	S- 51	22.85	0.914	105.4	117.1	11.7		29.8	519	87.15	12.72	0.23	0.00	87.26	12.74	$C_{37.7}H_{66.2}$	C_nH_{2n}— 9.2
	S-115	22.44	0.934	92.8	110.6	17.8		41.3	460	87.40	12.21	0.34	0.00	87.74	12.26	$C_{33.6}H_{56.4}$	$C_nH_{2n-10.8}$
	S- 40	22.60	0.935	87.8	107.0	19.2		44.2	451	87.26	12.23	0.31	0.00	87.71	12.29	$C_{33}H_{55.4}$	$C_nH_{2n-10.6}$
	P- 4	22.53	0.947	76.6	102.6	26.4		54.6	432	87.29	12.06	0.22	0.39 ?	87.87	12.13	$C_{31}H_{52.4}$	$C_nH_{2n-10.8}$

shown by an average mixture of the many single definite hydrocarbons which make up a lubricating oil; the same relative characteristics would also be shown by the individual hydrocarbon itself.

It is therefore clear that in the above mentioned cases the chemical constitution of oils can be indicated in a preliminary way; in conjunction with the specific gravity, therefore, certain regularities or groups of characteristics should be capable of classification.

With this in view the oils in question were subjected to an ultimate analysis. The most important results of these analyses are shown in Tables III and IV. Table III is a contnuation of Table I and contains the same groups of oils of like viscosity, while Table IV, a continuation of Table II, deals with oils of similar viscosity and also of similar specific gravity, for comparative purposes.

The content of aromatic hydrocarbons (column 4) was determined by the method of Sachanen and Wirabianz[7], using their coefficients; in this method the aniline point is determined before and after treatment of the oil with concentrated sulphuric acid, yielding the depressions shown in column 3; instead of employing the above method in every detail wherein the so-called maximum aniline points are determined, the figures shown in the table are the aniline points for a 1:1 mixture of oil and aniline. The apparent molecular weight (column 5) of the oils has been determined by the cryoscopic method of Epperson and Dunlop[8] using benzole as the solvent. The elementary analyses are shown in Tables III and IV, column 6, and in column 7 the analyses are recalculated for percent carbon and hydrogen on the basis of 100 percent pure hydrocarbon; such calculation is permissible where it is desired to eliminate extraneous elements as sulfur, nitrogen, ash, etc. The empirical formula for the oils (column 8) was calculated from the molecular weight and elementary analyses, and in column 9 is shown the approximate formula for the series of hydrocarbons to which the oils appear to belong.

Table III, column 4, can be interpreted to show that the content of aromatic-ring hydrocarbons increases consistently with an increase in the specific gravity of the oils of equal viscosity at 50°C. Inversely, the hydrogen content (column 7) naturally decreases in direct proportion; there is also a definite decrease in the aniline point of the oils freed of aromatic hydrocarbons (column 3); this is evidence that with an increase in the specific gravity of the oil that not only the aromatic hydrocarbons but also those of the naphthenic type predominate over the so-called "paraffinic" structures. The molecular weights (column 5) reveal unexpectedly the fundamentally different behavior or properties of the "paraffinic" and "naphthenic" lubricating oils. For instance, with a decrease in the specific gravity, there is an appreciable increase in the molecular weight, with which the higher average boiling point of the oil is also related. For example, in column 8 the average molecule of an oil of 4° Engler viscosity and 0.875 specific gravity is composed of 32 carbon atoms, as against the molecule of an oil of 0.932 specific gravity built up of only 27 carbon atoms. In the group of oils of 22 Engler

[7] Erdol u. Teer, 9, 170-172; 187-189; 202-203; 220-222, 1933.
[8] Jour. Ind. Eng. Chem., 24, 1369, 1932.

TABLE IV

Group	Sample No.	Vis. 50° C.	Sp. Gr. 20° C.	Aniline Point Deg. C. Before	Aniline Point Deg. C. After	Removal of Aromatic Hydrocarbons	Depression	Percent Aromatics	Apparent Mol. Wt.	Ultimate Analysis, Percent C	H	S	Ash	On Basis of Pure C H Hydrocarbon: Ultimate Analysis C	H	Apparent Formula	Apparent General Series
		1	2	3				4	5	6				7		8	9
A.	C-35	4.19	0.902	91.1	104.8	13.7		33.7	399	87.26	12.48	0.17	0.07	87.49	12.51	$C_{29.1}H_{49.9}$	C_nH_{2n}— 8.3
	C-36	4.22	0.902	89.3	102.2	12.9		32.0	404	87.18	12.56	0.19	0.02	87.41	12.59	$C_{29.5}H_{51.0}$	C_nH_{2n}— 8.0
C.	D- 4	10.90	0.931	84.3	99.4	15.1		36.4	413	87.44	12.23	0.26	0.07	87.73	12.27	$C_{30.2}H_{50.7}$	C_nH_{2n}— 9.7
	P- 6	11.06	0.931	87.2	104.2	17.0		39.8	405	87.45	12.27	0.30	0.06	87.78	12.22	$C_{29.6}H_{49.5}$	C_nH_{2n}— 9.7
D.	P- 4	22.53	0.947	76.6	102.6	26.4		54.6	432	87.29	12.06	0.22	0.39 ?	87.87	12.13	$C_{31.6}H_{52.4}$	$C_nH_{2n-10.8}$
	P- 5	22.31	0.947	79.8	106.7	26.9		55.7	454	87.48	11.96	0.41	0.10	87.98	12.02	$C_{32.3}H_{54.6}$	$C_nH_{2n-12.0}$

viscosity an oil of 0.886 specific gravity appears to contain 53 carbon atoms, while an oil of 0.947 gravity shows the presence of only 32 carbon atoms.

The above observations appear to be confirmed when the constants for well-identified members of lower hydrocarbon series comprising the lubricating oils, are tabulated from data existing in the literature; from such data one obtains the same above mentioned relationships as have been revealed in the present investigation. The calculated empirical formulae for the various series of hydrocarbons in the above tables reveal interesting facts; while such results are generally known to workers in this field, it is desirable to point them out once again. For instance, it appears clear that the so-called "paraffinic oils" hardly can be composed of true paraffins, since even in the case of the light pure Pennsylvania oil, C-34, which contains only 16.8 percent of aromatic type hydrocarbons, the formula C_nH_{2n-4} indicates the presence of threefold polynaphthenes. From the data at hand, one can also establish that with an increase in the "naphthenic" character of the oil (increase in specific gravity) there is a constant decrease in the number of side-chains in the polynaphthenic rings; finally, as in the case of the true "asphaltic-naphthenic" oils only the purely aromatic and naphthenic rings predominate.

According to the data presented and the above discussion, one can expect then that the oils shown in Table IV, which are of equal viscosity and of equal specific gravity to be of similar chemical make-up or constitution. This has been substantiated since the oils that have been compared show practically the same aromatic contents, molecular weight, and elementary analyses, and, therefore, also the same calculated empirical formula.

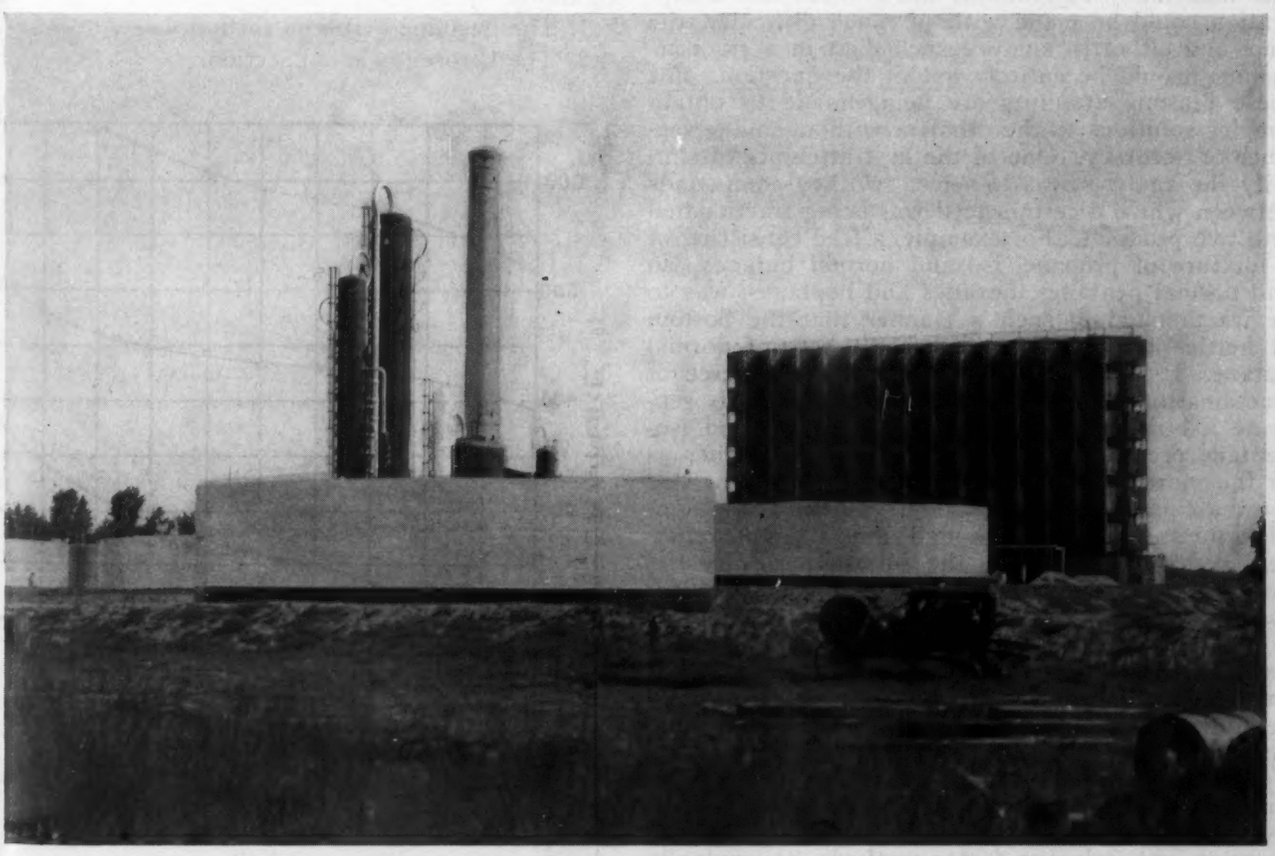
SUMMARY

For refined normal petroleum lubricating oils of similar viscosity at 50°C., the specific gravity appears to be characteristic, and indicates the average chemical composition of the oil, as well as those properties directly dependent on composition.

The average boiling point, aniline point, apparent molecular weight and hydrogen content decrease directly with an increase in the specific gravity; at the same time there is a simultaneous increase in the slope of the viscosity-temperature curve (lower viscosity-index), the carbon content generally diminishes, while the content of aromatic or reactive hydrocarbons, and in a broad sense, the oxidation susceptibility of the oil increases.

Many of the above discussed properties of lubricating oils are, of course, influenced and obscured by several factors; for instance, such as by the method of refining, whereby oils can be finished up still containing variable amounts of asphaltic or other coloring matter, or where processing results in the presence of appreciable amounts of hard paraffins, or in those cases where extraneous elements are present, such as sulphur, nitrogen or ash, etc.; the analytical constants are further affected by the presence of added compounds and synthetic preparations that are often added to lubricating oils.

This investigation was undertaken with the financial assistance of the "Szechenyi Scientific Society Dedicated to the Aid of Hungarian Scientific Research" in Budapest, to whom I am gratefully indebted.



An East Texas Refining Plant.

Efficiency of Petroleum
Fractionating Columns

PART IV

The efficiency of different sections of a commercial bubble plate column

C. W. CANNON*
Shell Petroleum Corporation, Houston, Texas
and
R. L. HUNTINGTON
School of Petroleum Engineers, University of Oklahoma

IN a recent paper[2], the authors have stressed the importance of the study of laboratory fractionating columns in their relationship to the analysis of the efficiency of a commercial petroleum distillation tower. Garton and Huntington[3] analyzed the gasoline-kerosene section of this same tower (Figure 1) when it was operating on crude oil from the Tonkawa field of Northern Oklahoma. At that time the true boiling point distillations of the gasoline and kerosene cuts were made in a glass column 1¼ inches I. D. and having a section 5 feet in height packed with small glass nipples.

Engineers realize the futility of separating such commercial fractions as motor fuels, kerosene, etc., into their many compounds, and granted such a separation could be made without much difficulty, the time and effort to analyze such data in a rigorous manner would be entirely out of the question. For these reasons attempts are being made to obtain simpler solutions to the problem without undue sacrifice of accuracy. One of the first attempts to simplify the analysis was to select two key compounds between which a certain feed was being fractionated into two products. For example, a feed consisting of a mixture of propane, iso and normal butanes, iso and normal pentanes, hexanes and heptanes, was to be fractionated in such a manner that the bottom or kettle product was substantially free of normal butane. It was proposed that the same degree of fractionating efficiency would be required to separate a binary mixture of normal butane and isopentane present in the same ratio to each other as in the more complex mixture, as would be needed for the equivalent fractionation with the more complex mixture itself. Although this attempt represented good approach to the solution, it since has been proven that fewer plates would be required for the separation of the more complex mixture, due no doubt to the fact that the propane and iso-butane would tend to pull the normal butane overhead while the hexanes and heptanes would attract the normal pentane toward the base of the column. Obryadchakoff[5] has made a noteworthy contribution toward the simplification of the analysis of refinery columns by the use of ASTM distillations of the products. Recently Brown, Souders et al[1] have found that the absorption and stripping factor methods, as originally offered by Kremser[4], are reliable as compared with theoretically rigorous calculations. Their studies were confined to gas and natural gasoline fractionators.

In this present investigation, the two upper sections of a commercial tower (Figure 1) were analyzed, by selecting two key components representative of the average molal boiling points of the overlapping fractions of the respective products. In an effort to make such studies more practical, i. e., less time consuming, a Hempel column was selected as a measuring stick for the analysis of the three commercial products, gasoline, kerosene and gas oil which were made from the two sections under investigation:

1. The gasoline-kerosene section.
2. The kerosene-gas oil section.

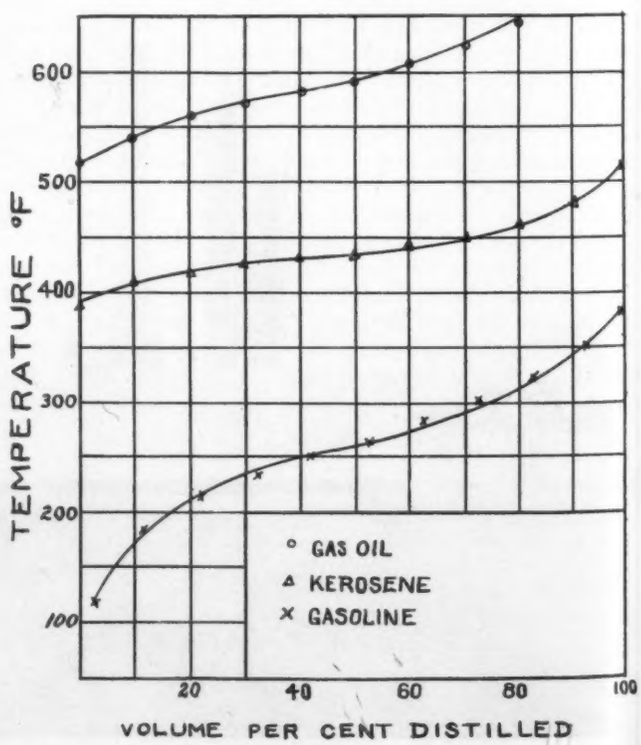


FIGURE 2
A. S. T. M. Distillations on straight run products from Oklahoma City Wilcox crude oil.

*Mr. Cannon was an undergraduate student at the University of Oklahoma when this material was prepared and it was a part of his undergraduate thesis for 1935.

PLANT DATA

Duration of run — 28 hour straight distillation of Oklahoma City Wilcox crude oil. Gravity — 36.6° A.P.I.

16,400 gallons crude charge—	A.P.I.	Est. Mol. Wt.	Mols
1670 gallons gas oil	34.5	275	43.4
2335 gallons kerosene	42.0	180	88
3700 gallons gasoline product	58.0	115	192

425 gallons of water (steam condensate) used as stripping steam in column.

Temperature at the top of tower 260° F.

Temperature at the bottom of the gasoline-kerosene section 420° F.

Temperature at the bottom of the kerosene-gas oil section 540° F.

Temperature of crude flashing into tower, 20 feet above base, 750° F.

Pressure on tower 14.2 pounds/square inch absolute.

Orifice differential manometer data for measurement of gasoline reflux:
- Sp. gravity of gasoline 0.7467.
- 1 gallon of gasoline 6.216 pounds.
- Head of water on gauge 28 in. water (indicated differential).
- Diameter of pipe 1.4688 inches.
- Diameter of orifice 0.764 inches.

Calculations:

Gasoline reflux

$$h = \frac{28}{12} \times \frac{1 - 0.7464}{0.7464} = 0.792 \text{ ft. gasoline} \quad \left(\text{Actual differential across orifice.}\right)$$

$$u_2^2 - u_1^2 = C^2 \times 2g \times h$$

$C = 0.61$ for sharp edged orfice

$2g = 64.4$

$$u_1/u_2 = \left(\frac{\frac{0.764}{12}}{\frac{1.4688}{12}} \right)^2$$

$u_1 = 0.270\, u_2$

Then

$u_2^2 - 0.073\, u_2^2 = 0.61^2 \times 64.4 \times 0.792$

$0.927\, u_2^2 = 18.95$

$$u_2^2 = \frac{18.95}{0.927} = 20.4$$

$u_2 = 20.4\frac{1}{2} = 4.16$ ft/sec. velocity of gasoline through orifice.

$$\text{Area of orifice} = \frac{\pi}{4} d^2 = (0.7854) \times \left[\frac{(0.764)}{(12)} \right]^2$$

$= 0.00318$ ft.²

Volume gasoline per sec. $= 4.16 \times 0.00318 = 0.0132$ ft³/sec.

$0.0132 \times 62.4 \times 0.7467 = 0.606$ # gasoline/sec.

$0.606 \times 60 = 36.36$ #/mim.

$$\frac{36.36}{6.216} = 5.84 \text{ gal./min. of gasoline reflux.}$$

$$\frac{3700}{28 \times 60} = 2.2 \text{ gal./min. of gasoline product.}$$

$$\frac{5.84}{2.2} = 2.65 \text{ reflux ratio} = \frac{\text{Reflux}}{\text{Product}} \quad \text{or}$$

$$\frac{2.65}{3.65} = .726 \frac{\text{Reflux}}{\text{Vapor}}$$

Velocity of vapor through free area of tower, in gasoline-kerosene section.

$$\text{T avg.} = \frac{420 - 260}{\ln\left(\frac{420}{260}\right)} = \frac{160}{\ln 1.615} = 334°\text{F.}$$

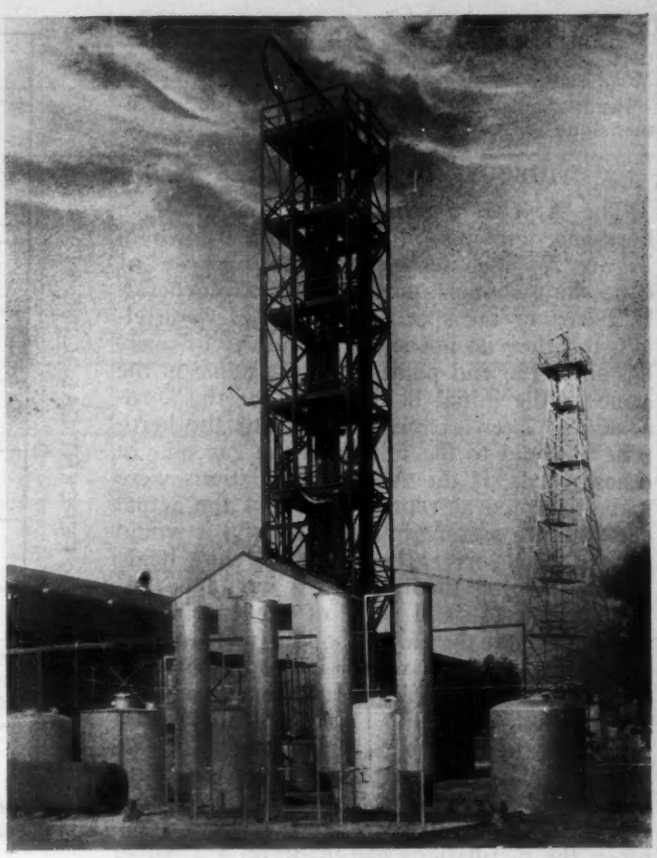


FIGURE 1

Commercial size distillation unit Petroleum Engineering Laboratory, University of Oklahoma.

$$\frac{\text{Gal. gaso./sec.}}{28 \times 3600} \times \frac{3700 \times 3.65}{\text{Mol. gaso./sec.}} \times \frac{6.216}{115} \times \frac{\text{cu. ft./sec. @ s. c.}}{359} \times \frac{\text{cu. ft./sec. @334°F.}}{794} \times \frac{14.7}{492} \times \frac{14.7}{14.5} =$$

4.17 cu. ft. gasoline/second.

$$\frac{\text{Gal. } H_2O\text{/sec.}}{28 \times 3600} \times \frac{425}{\text{Mol. } H_2O\text{/sec.}} \times \frac{8.33}{18} \times \frac{\text{cu. ft. } H_2O\text{/sec. @ s. c.}}{359} \times \frac{\text{cu. ft. @ 334°F.}}{794} \times \frac{14.7}{492} \times \frac{14.7}{14.5} =$$

1.145 cu. ft. steam/sec.

Total volume of vapor $= 4.17 + 1.145 = 5.33$ cu. ft./sec.

$$\text{Free area of tower} = \frac{\pi}{4}(3)^2 = 7.07 \text{ sq. ft.}$$

$$\text{Vapor velocity} = \frac{5.33}{7.07} = 0.755 \text{ ft./sec.}$$

Number of actual trays in gasoline-kerosene section; including one partial condenser for gasoline vapor	9
Number of actual trays in kerosene stripping section	3
Total number of actual trays in gasoline-kerosene section	12

Just above the kerosene stripping section 70 percent (by volume) of the liquid overflow was refluxed into the top of the kerosene-gas-oil section, and the other 30 percent was taken off as kerosene from the kerosene stripping section.

Number of actual trays in kerosene-gas-oil section	9
Number of actual trays in gas-oil stripping section	3
Total number of actual trays in kerosene-gas-oil section	12

Just above the gas-oil stripping section 60 percent (by volume) of the liquid overflow was refluxed into the top of the gas-oil light lub. section; and the remaining 40 per-

cent was taken off as gas-oil from the stripping section.
Molal ratio steam to gasoline vapor = 0.275
Inside diameter of tower = 3 ft. For other dimensions please refer to[3].

DISCUSSION OF RESULTS

The ASTM distillations of the gasoline, kerosene, and gas oil products are shown in Figure 2. Such tests serve the purpose of controlling refinery products, and are generally a part of the specifications of every product, but they do not show the degree of overlap since the end point of the gasoline is the same as the initial boiling point of the kerosene, and likewise the end point of the kerosene is equal to the initial on the gas oil. In other words, if the ASTM distillations were to be accepted as representative of the actual constituents present in the products, it would appear that perfect fractionation were being attained. Even theoretically it would be impossible for the end point of the gasoline to be lower than the initial boiling point of the kerosene, for there would have to be a disappearance of a naphtha fraction for such a phenomenon to occur. That overlapping does occur is readily seen by a glance at Figure 3, showing that the end points of gasoline and kerosene are higher than the initial boiling points of kerosene and gas oil respectively when the distillations are made on a Hempel column. Difficulty with hold-up in the packing accounts for the fact that the end points had to be extrapolated.

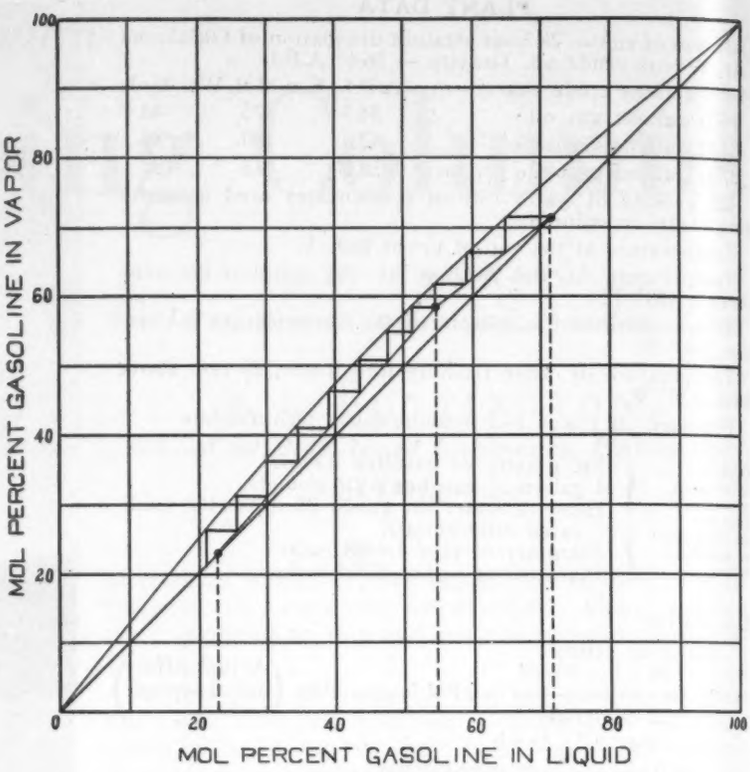


FIGURE 4

McCabe-Thiele diagram showing the number of theoretical trays in the gasoline-kerosene section.

$$\textit{Efficiency} = \frac{10.75}{12} \times 100 = 89.6\%$$

SELECTION OF THE KEY COMPONENTS

(1) *Gasoline-kerosene section — Oklahoma City crude oil run.* On Figure 3, it is easily seen that the average boiling point of the overlapping fractions between gasoline and kerosene is about 375° F. On this basis, gasoline was defined as all material boiling above 375° F. The average boiling point of the gasoline component present was taken as 367° F. while the corresponding key component for the kerosene present in the higher boiling portions of the gasoline was 390° F.

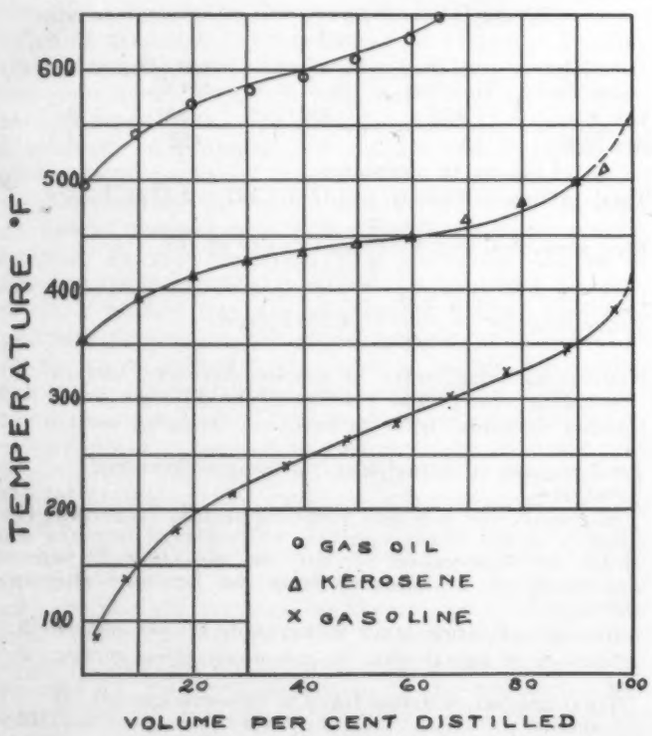


FIGURE 3

Hempel distillation on straight-run products from Oklahoma City Wilcox crude.

Taking these two key components as the actual hydrocarbons which were to be fractionated, vapor pressures were obtained on the Brown-Coats chart between 367° F. and 390° F. for the two components, from which a vapor-liquid equilibrium diagram was drawn. (See Figure 4 and Table I.)

TABLE 1

	Vapor Pressure lbs./sq. in./abs.		Gasoline component Mol Fraction	
Temp. °F.	Gasoline Component	Kerosene Component	X In liquid	Y In vapor
367	14.2	10.50	1.000	1.000
375	15.5	11.40	.683	.747
383	17.1	12.60	.356	.428
390	19.0	14.20	.000	.000

Having obtained the equilibrium diagram at a constant pressure of 14.2 pounds per square inch, under which the tower was operating, the next step was to determine the mol percentages of the two key components in the overhead product (gasoline) and the bottoms (kerosene). By making a material balance around the gasoline-kerosene section, the mol percentages of the key components could readily be calculated for the feed, which consisted of vapor coming from the gas oil section below the gasoline-kerosene section. For the overhead product, it was estimated from the Hempel distillation of the gaso-

line, that 71.5 mol percentage of the two key components in the overhead products consisted of hydrocarbons having an average boiling point of 367° F. which corresponds to the gasoline key component. In a similar manner, it was found from the Hempel distillation of the kerosene that 22.2 mol percentage of the two key components in the bottoms consisted of hydrocarbons having an average boiling point of 367° F. Reference to the plant data shows the mols of each commercial product coming from the tower, and these quantities must be taken into consideration in calculating the composition of the feed based on the presence only of the two key components. For example in the case of the gasoline-kerosene section, the mols of gasoline are 2.175 times as many as the mols of kerosene. Therefore the composition of the two component overhead mixtures consisting of 71.5 percent gasoline would have to be multiplied by 2.175 and the bottom product by 1.0 in order to get the composition of the two component system in the feed, represented by the central vertical dotted line. The bottoms and overhead are represented by the left and right hand vertical lines respectively. The efficiency of the section equals 89.6 percent (see Figure 4). The kerosene-gas oil section was analyzed in the same manner as the gasoline-kerosene section. The efficiency of this section is 86.7 percent (see Figure 5).

When Garton and Huntington[3] made a study of this same tower a year ago, they obtained data on the distillation of a Tonkawa crude oil which is somewhat higher in gasoline content. In analyzing the gasoline-kerosene section two key components were selected, however, in determining the composition of the overhead product with respect to the gasoline key component, the mol percentage of those components in the gasoline product boiling below a temperature of 400° F. was taken as the percentage of gasoline in the overhead. These data have been recalculated on the basis of the two key components only, the result of which are shown in Figure 6. The lower efficiency might be the result of the higher mass velocity under which the tower was being operated when it was processing the Tonkawa crude. The linear vapor velocity on the Oklahoma City crude run was .755 feet per second and on the Tonkawa crude 1.34 feet per second. Although higher linear velocities are favored in view of the better contact which may be obtained between the rising vapor and the descending liquid, it is readily seen that the efficiency of fractionation falls off in commercial towers just as it does in laboratory columns, when the rate of product removal is increased. Another cause for the apparently much lower efficiency in the Tonkawa crude run is, no doubt, due to the fact that the products were analyzed in the 5-foot column instead of the Hempel column.

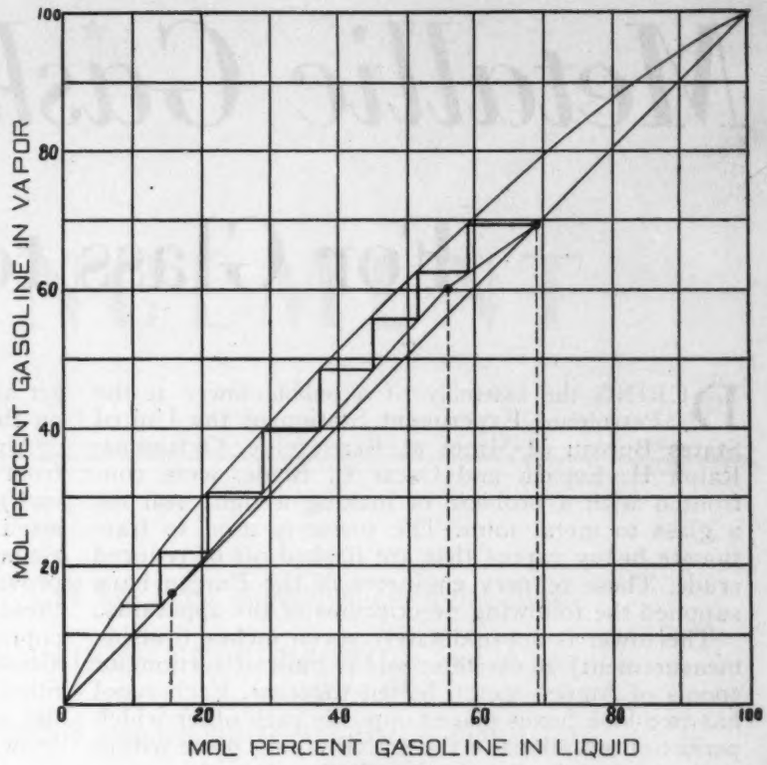


FIGURE 6

McCabe-Thiele diagram showing number of theoretical trays in gasoline-kerosene section. Column was operated on Tonkawa crude with a 2 to 1 reflux ratio.

$$Efficiency = \frac{6.66}{12} \times 100 = 55.5\%$$

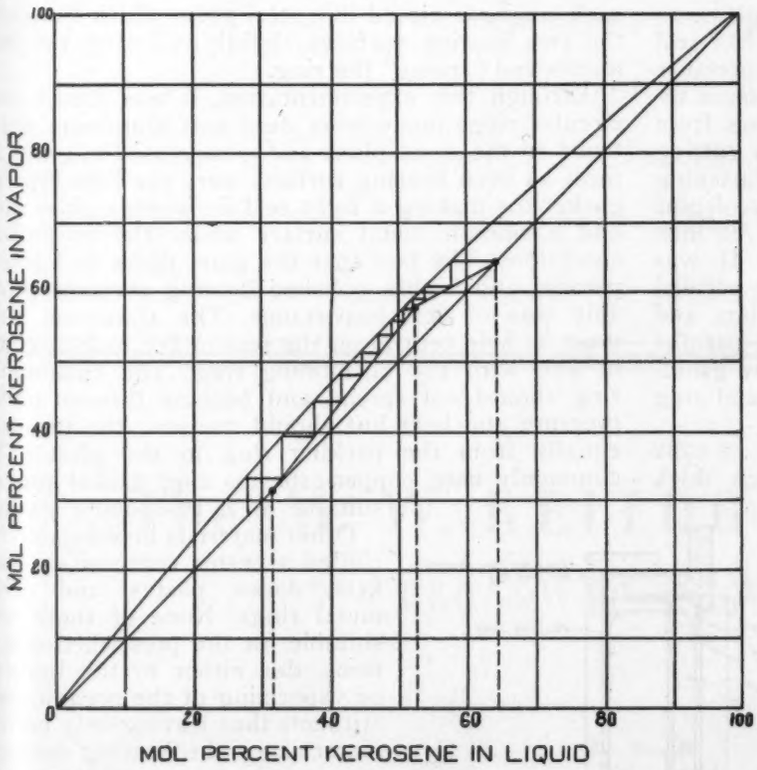


FIGURE 5

McCabe-Thiele diagram showing the number of theoretical trays in erkosene-gas oil section.

$$Efficiency = \frac{10.4}{12} \times 100 = 86.7\%$$

[1]Brown, G. G.; Souders, Mott, Jr., et al — Ind. Eng. Chem. 27, 383 (1935).
[2]Cannon, C. W., and Huntington, R. L.—Refiner, 14, 424 (1935).
[3]Garton, V. W., and Huntington, R. L..—Refiner, 14, 60 (1935).
[4]Kremser—National Petroleum News, 43 (May 21, 1930).
[5]Obryandchakoff—Ind. Eng. Chem. 24, 1155 (1932).

Metallic Gaskets

For Glass to Metal Joints*

DURING the assembly of a bubble tower at the Petroleum Experiment Station of the United States Bureau of Mines at Bartlesville, Oklahoma, Ralph H. Espach and Oscar C. Blade, were confronted with a problem of making a tight seal for a glass to metal joint. The tower is used to fractionate heavy vapors that are flashed off of reduced crude. These refinery engineers of the Bureau have supplied the following descriptions of the apparatus:

The tower is approximately seven inches (outside measurement) in diameter and is built of sections or spools of Ampco metal, bolted together. Each spool has two look-boxes placed opposite each other which permit observations of the action taking place within each spool and on each tray. Reduced crude was to be heated to not over 800°F. and flashed into the bubble tower at a reduced pressure, possibly not lower than 10 mm. absolute. The approximate range of tower temperatures was from 750°F. at the base to 500°F. at the top.

Figure 1 shows the design of the look-boxes. The assembly problem was to make a tight joint between parallel faces of Ampco metal and Pyrex glass. to be effective this joint had to maintain a perfect seal at elevated temperatures against a reduced pressure and remain tight when temperature and pressure returned to normal. The sheets of Pyrex glass from which the glass disks were cut were made by cutting the blown cylinders longitudinally and flattening them. The disks, as first used had tolerances of plus or minus 1/32 inch diameter and 1/64 to 1/32 inch variation in thickness for any one glass. It was found that the surfaces of the glass must be parallel between the two metal surfaces of the look box, and the packing ring and the disks were given parallel faced borders approximately ¼-inch wide by grinding with valve grinding compound on a metal ring of the required diameter.

Copper-covered asbestos gasket rings 2-1/32 inches I.D. and ⅛ inch wide by 1/16-inch thick (elliptical in cross section) held satisfactorily in preliminary tests, but after several heatings small leaks developed. Examination showed the gasket had compressed appreciably and presented a flat surface, ⅛-inch wide. The gasket, however, still retained some "springiness" and was adopted as the upper gasket between the glass and metal collar, to act as a cushion and to maintain an even pressure on the glass.

Aluminum rings, 2-1/16 inches I.D., were made from dead soft aluminum wire, gage 12B&S (.081 inch). The ends were carefully welded together and sized to a perfectly uniform circle. To keep the rings centered under the glass disks—for they proved successful only after it was determined that these gaskets must be placed directly under the copper covered asbestos ring gaskets above them—asbestos composition rings were used, which just filled the space to the side of the look-box seats but did not rise above the rings. A joint of this type showed some leakage, and it was thought that the ground surface of the border of the glass disk presented too many pits even for the soft aluminum. Accordingly, glass disks were obtained whose faces had been ground and polished until accurately plane and parallel. It was noticed also that the aluminum rings had fine markings on them as if they had been finished by filing or had been abraded by moving against a rough surface. To overcome this objection each ring was placed in a steel press which flattened the two bearing surfaces slightly, effacing the fine marks and "truing" the ring.

Through this experimentation, it was found that circular rings made from dead soft aluminum wire, trued to the same plane and compressed slightly to form an even bearing surface, were the best type of gasket for making a tight seal between a glass disk and a smooth metal surface under the prescribed conditions. The fact that the glass disks had plane, parallel and highly polished bearing surfaces probably was of first importance. The aluminum ring must be held central on the seat of the look-box and in line with the cushioning ring. The cushioning ring should not spread and become thinner under pressure and heat but should transmit the pressure equally from the packing ring to the glass. The commonly used copper-asbestos ring gasket proved suitable as a cushioning gasket.

Other materials investigated included asbestos composition gaskets, dopes, pastes, and other metal rings. None of these was suitable for the prescribed conditions, due either to the burning or vaporizing of the organic constituents thus leaving only porous material, or the bearing surfaces were not in even continuous contact because of unevenness in the material.

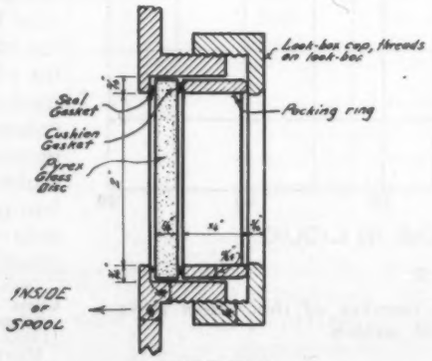


FIGURE 1

Lookbox detail.

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RELIABILITY
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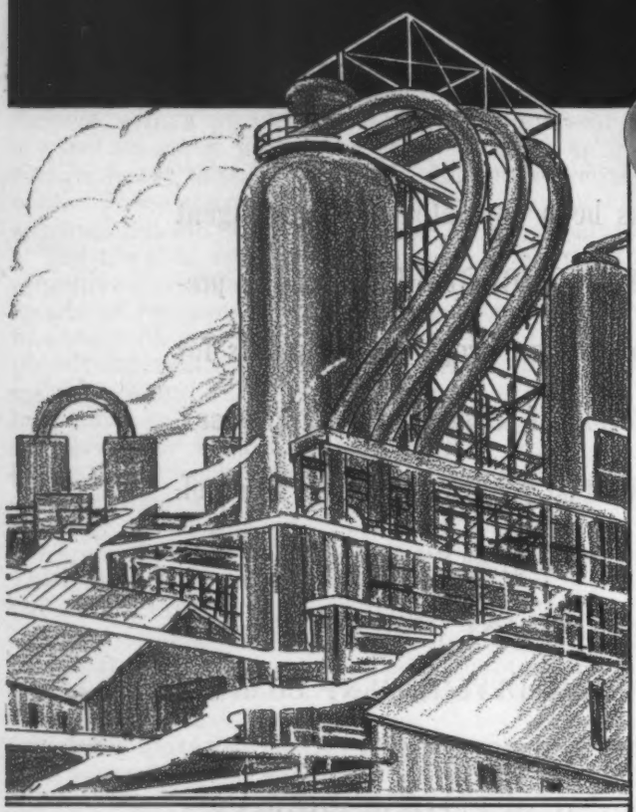

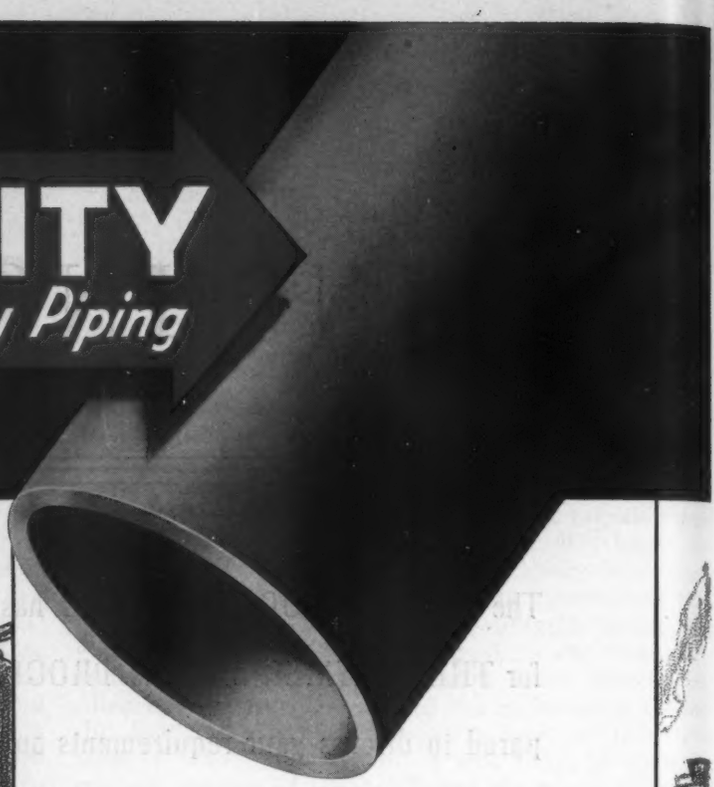

In modern refineries, where high pressures, high temperatures, and severe corrosive conditions are involved, reliability of equipment would seem to be the paramount consideration. Here the elements of direct cost, of safety, and of continuous operation can be turned toward either success or failure. This is why leading refiners, continually on the search for new and better tubular material, are turning more and more to National Tube Company 4%—6% Chromium Pipe and Tubes for still tubes and also for furnace tubing, hot oil lines, tubular parts of heat exchangers, condenser tubing, return bends, etc.

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thousand cubic feet of gas treated 30 to 60 percent conversion is claimed on liquid charge basis), with production cost per gallon running relatively low, it is not without the realm of reason to not only expect "poly" plants wherever there is a battery of cracking units, but also to expect, in time, the establishment of polymerization units for operation on natural gas. Certain it is that the "poly" plant will come to the refineries rather rapidly in its present stage of development and remove some of the functions of the present absorption gasoline recovery systems.

At the New York meeting of the American Chemical Society it was pointed out that the production of gas from cracking operations in the United States totaled 300,000,000,000 cubic feet annually and at that time it was estimated that with the known developments in polymerizing the olefin hydrocarbons in this gas it would be possible to produce 1,000,000,000 gallons of gasoline annually, or more than five percent of the total motor fuel production for the country. It was also stated that through cracking or pyrolysis of paraffin hydrocarbons to form olefins and that followed by the polymerization of the olefins, natural and refinery gases, excepting methane, could theoretically produce a motor fuel supply equal to the 500,000 barrels daily production secured by present cracking operations, or somewhat above 40 percent of the country's total production.

Special Trains to Institute's Annual Meeting

PREPARATIONS for the 16th annual meeting of the American Petroleum Institute at Los Angeles, include plans not only for special trains but also for an "Oil Men's Caravan."

The "Caravan," arrangements for which are being made by R. A. "Dick" Wotowich, of Warner-Quinlan Company, 2 Park Ave., New York, will permit oil men attending the meeting to make the trip without thought for details once they go aboard a chartered train. Meals, berths, schedules, changes, automobile and bus hire, tips, and other miscellaneous items will be taken care of by the "Caravan" managers and without further thought on the part of the "Caravaneers." Reservations will be available to oil men at New York and to those leaving from cities enroute, but the managers will permit use of the train to none except active oil men.

Reservations already have been made by delegations from New York, Pennsylvania, Ohio, Washington, D. C., and Illinois. The "Caravan" will follow the routes of the Pennsylvania, Missouri Pacific, Denver & Rio Grande Western, and Union Pacific lines.

The New York Central and Santa Fe railroads have announced plans for operating the "American Petroleum Institute Special" as a de luxe train for members and their families attending the annual meeting. Modern air-conditioned Pullman equipment will be provided, with club, observation, lounge, dining, compartment, drawing room and open section sleeping cars. Valet, maid, and barber shop service, as well as daily market reports and news bulletins, will be available. Opportunity will be had for sightseeing or stopovers on the return trip, and different routes may be followed.

The Look Box

(Continued from page 456)

The special leaves New York on the Central lines at 4:15 p. m., Thursday, November 7, leaves Albany at 7:10 p. m., and Buffalo at 1:02 a. m., Friday, The special leaves Chicago on the Santa Fe lines at 12:30 p. m., Friday, leaves Albuquerque, N. M., at 7:05 p. m., Saturday, November 9, and arrives at Los Angeles at 4:00 p. m., Sunday, November 10.

Southern Pacific Special to Los Angeles for A.P.I. Meet

The Southern Pacific Lines have announced a special train for the accommodation of those going from the Southwest to attend the convention of the American Petroleum Institute, at Los Angeles, November 11-14. The company will operate special train consisting of Pullman sleeping cars, sections, compartments and drawing rooms, club car and dining car on the following schedule from Houston, Texas.

Lv. Houston	9:20 a.m.		Nov. 8
Lv. San Antonio..	3:00 p.m.		Nov. 8
Ar. El Paso.....	7:15 a.m.	CT	Nov. 9
Lv. El Paso.....	7:30 a.m.	MT	Nov. 9
Ar. Los Angeles..	8:00 a.m.		Nov. 10

Delegates from Beaumont, Lake Charles, New Orleans and east may use our Train No. 1, arriving Houston at 9:00 a.m., November 8, connecting with the above special train at Houston. Those from Dallas, Fort Worth, Waco, Austin and other cities in North and Central Texas, as well as Oklahoma points, can reach Houston Southern Pacific regular train service 7:10 a.m., November 8, connecting with special train.

Conventions

N. A. L. G. M. The National Association of Lubricating Grease Manufacturers will hold its annual meeting, October 14-15, in Chicago at the Hotel Stevens.

A. G. A. The American Gas Association, Manufacturers Division, will meet at Atlantic City, October 14 to 18.

N. S. C. National Safety Council holds the twenty-fourth annual Safety Congress, in Louisville, Kentucky, October 14-18.

I. P. A. Independent Petroleum Association will hold its sixth annual meeting at Dallas, Texas, November 4 and 5.

A. P. I. The American Petroleum Institute will hold its 16th annual meeting at the Biltmore Hotel, Los Angeles, November 11-14.

C. N. G. A. The California Natural Gasoline Association holds its meeting the first Thursday of every month at announced meeting place.

Louisiana-Arkansas Refiners Association, Technical Division holds monthly technical group meetings the second Friday of each month at announced meeting place.

Institute Committees to Make Broad Survey

A broad survey of problems peculiar to the production, refining, marketing, and transportation operations of the petroleum industry, with particular reference to economic factors, will be made by four committees created by the American Petroleum Institute.

It is expected that the committees, which were appointed by the national trade association's executive committee, will make their preliminary reports in time for presentation before the Institute's board of directors, and perhaps the membership, at the Institute's sixteenth Annual Meeting scheduled for November 11 to 14 at Los Angeles.

J. Edgar Pew, Sun Oil Company, Philadelphia, is chairman of the production committee, which is to hold its organization meeting at Dallas, Texas, on Wednesday, September 18. J. Noel Robinson, of Tide Water Oil Company, New York, has been appointed chairman of the refining committee, which met for the first time in New York September 17. W. V. Hartmann, of Gulf Refining Company, Pittsburgh, is chairman of the marketing committee, which met September 18, at New York. Harry T. Klein, The Texas Company, New York, is chairman of the transportation committee, which met at New York, September 20.

Following is the membership of the committees:

Production: Chairman Pew; A. I. Leverson, Fergus Falls, Minnesota; W. B. Heroy, Consolidated Oil Corporation, New York; Frank R. Clark, Mid-Kansas Oil & Gas Company, Tulsa; Fred H. Lahee, Sun Oil Company, Dallas; Wallace E. Pratt, Humble Oil & Refining Company, Houston; J. Y. Snyder, Shreveport, Louisiana; R. S. McFarland, Texas Seaboard Oil Company, Dallas; G. C. Jester, Standard Oil Company of California, San Francisco; Alex W. McCoy, Maryland Royalties Company, Ponca City; E. L. DeGolyer, Felmont Oil Company, New York; J. H. Gardner, Gardner Oil Company, Tulsa; L. P. Garrett, Gulf Production Company, Houston; Max Ball, Denver, Colorado; Alexander Deussen, Houston; and W. E. Rather, Dallas.

Refining: Chairman Robinson; A. E. Pew, Jr., Sun Oil Company, Philadelphia; George H. Taber, Jr., Sinclair Refining Company, New York; R. E. Wilson, Pan American Petroleum and Transport Company, New York; W. L. Stewart, Jr., Union Oil Company, Los Angeles; C. M. Boggs, Kanotex Refining Company, El Dorado, Kansas; Lloyd F. Bayer, Associated Oil Company, San Francisco; Charles B. Buerger, Gulf Refining Company, Pittsburgh; and Stuart A. Giraud, Humble Oil & Refining Company, Houston.

Marketing: Chairman Hartmann; H. W. Dodge, The Texas Company, New York; W. T. Holliday, Standard Oil Company of Ohio, Cleveland; Allan Jackson, Standard Oil Company (Indiana), Chicago; C. B. Watson, Pure Oil Company, Chicago; J. W. Carnes, Sinclair Refining Company, New York; Jacob France, Mid-Continent Petroleum Corporation, Baltimore; R. R. Irwin, White Eagle Oil & Refining Company, Kansas City; B. I. Graves, Associated Oil Company, San Francisco; D. E.

Buchanan, Hanlon-Buchanan, Tulsa; and Ralph K. Davies, Standard Oil Company of California, San Francisco.

Transportation: Chairman Klein; D. S. Bushnell, Northern Group Pipe Lines, New York; J. J. Cosgrove, Continental Oil Company, New York; C. E. Crawley, Consolidated Oil Corporation, New York; E. J. Henry, Atlantic Refining Company, Philadelphia; A. W. Peake, Standard Oil Company (Indiana), Chicago; and O. D. Donnell, Ohio Oil Company, Findlay.

Expanding Petroleum Vocational Training

EXTENSION into Kansas, Louisiana, California, and Arkansas of evening vocational training courses for workers in the petroleum industry is being considered by the American Petroleum Institute's Topical Committee on Vocational Training. Some 5,000 workers participated in vocational studies sponsored jointly by the state governments of Texas and Oklahoma, the federal government, and the petroleum industry in the fiscal year ended June 30 last, and the committee has been informed that demand for extension and expansion of the work is growing.

A new course on driving motor vehicles, designed to aid in preventing traffic accidents, is to be added to Texas courses conducted by Ray L. Martin, of the University of Texas, Austin, this year. A new course on natural reservoir conditions is being prepared for final approval by W. Fred Heisler, of Oklahoma A. & M. College, Stillwater. A conference of teachers engaged in conducting classes for petroleum industry workers is scheduled for Tulsa, at an early date.

Consideration is being given also to the possibility of establishing a course for foremen, with particular emphasis placed upon the problems of the industry. Mr. Martin is chairman of the committee appointed to make tentative plans for the course, with G. O. Lockwood, of the Empire Companies, Bartlesville, Oklahoma, and J. L. Risinger, Magnolia Petroleum Company, Dallas, Texas, as members.

Arrangements have been made whereby workers living at points distant from communities where vocational classes are held may take the courses by correspondence. The state departments of Texas and Oklahoma are making text books used in the courses available to those forwarding requests from other states, and from foreign countries, including Hawaii, Venezuela, Canada, and Brazil.

The courses are designed to give workers in the petroleum industry an opportunity to train themselves to meet increasing demands of present jobs.

"There is no place in a modern industry, such as the petroleum industry, for the strong back and weak mind," it was explained by representatives of the Texas State Board for Vocational Education. "In meeting modern conditions, brain is more important than brawn. Rule of thumb methods are giving way to exact methods. The man who does not grow with his job is sure to be out-distanced and compelled to surrender his place to his more progressive neighbor. With training available for the asking, every man is, to a large degree, master of his own fate. His present outlook may not be bright, but if he is prepared, perhaps some day his chance will come."

Any worker is privileged to enter any of the classes, which are held in public school buildings, which may help him in his daily work or fit him for promotion to a better job.

Classes are organized whenever 10 or more men express a desire for vocational training along certain lines. They are held, usually twice weekly, during the men's free time and wherever facilities are available for instruction. Each unit course covers a 12-week period, and each student contributes $2 per course. Courses include oil field mathematics, internal combustion engines, steam power, geology, rig building, methods of lifting oil, oil and gas separation, pipe fitting, oil field methods, care and use of equipment, transportation, lubrication, instrument reading, reservoir repressuring, etc.

Annual Survey of Refineries Published

THE Bureau of Mines has released Information Circular No. 6850 "Petroleum Refineries, Including Cracking Plants, in the United States, January 1, 1935." This is the annual survey of operating, shut down, and building refineries and cracking plants which the bureau has prepared for the benefit of the petroleum refining industry for the past several years. It includes a well rounded out discussion of the refining situation developed by G. R. Hopkins, acting chief economist, Petroleum Economics Division, Bureau of Mines, and E. W. Cochrane, statistical clerk, with the bureau. The report includes a recapitulation of refineries by years from 1914 to 1935, also by districts, by types of refineries, and by states. There is a recapitualtion of pipe stills operating, shut down and building which gives daily charging capacity of pipe stills for various uses. In addition there is a table of cracking units presented by year, by refining districts, by states and by types of processes. These cracking unit tables give only percentage and no longer give the number of units in operation. The major list of refineries is presented alphabetically by states, giving company name, location, railroads, straight distillation capacity, status and type, and cracking by capacity, status and type. Copies can be secured free by writing the Information Division, United States Bureau of Mines, 900 F Street, N.W., Washington, D. C.

"Base" of a Crude Oil

REPORT of Investigations No. 3279 "Base of a Crude Oil" has been prepared recently by the United States Bureau of Mines, Washington, D. C., with E. C. Lane and E. L. Garton as the authors. In this revised classification the three classes—paraffin, intermediate and naphthene—are retained but defined more closely. Four additional classes—paraffin-intermediate, intermediate-paraffin, intermediate naphthene and naphthene-intermediate—are described in detail. In addition, the presence or absence of wax in each sample is indicated; for example, oils may be described as paraffin base, wax bearing, or naphthene base, wax bearing, and so on. The table included in the bulletin gives analyses of seven crude oils, each typical of a class.

Gasoline Consumption Gains 3.95 Per Cent

GASOLINE consumption in the United States during the first six months of 1935 increased 3.95 percent, or 305,942,000 gallons, over that for the first half of 1934, it is reported by the American Petroleum Institute.

The institute's report is based upon the quantity of gasoline reported for tax or inspection in the various states, but reflects, as nearly as is possible to obtain the figures, consumption throughout the country. It is explained that gasoline tax evasion, and changes in basic laws under which data were collected throughout the period, may have disturbed the comparability of reports for various states.

New York retained its position as the largest consuming state with consumption totaling 723,640,000 gallons as against 718,270,000 in the first half of 1934. California again was in second place, with consumption of 685,611,000 gallons against 675,626,000 in the first six months of last year.

Pennsylvania, third largest consuming state, reported consumption of 555,774,000 gallons against 526,010,000. Illinois was fourth, reporting consumption of 485,245,000 against 474,516,000.

Decreases were shown in three states. Arkansas' consumption was 64,611,000 gallons against 65,545,000. Missouri reported consumption of 231,835,000 gallons as compared with 233,237,000. Consumption in Nebraska was 103,718,000 against 108,468,000 gallons.

Relative Merits of Gas Testing Methods

REPRESENTATIVES of a number of Mid-Continent oil companies have recently been engaged in conducting a series of field tests in the old Burbank pool of Oklahoma, to determine the gasoline content of natural gas as shown by the results obtained by different methods and individuals at a common source. Sponsored by the Natural Gasoline Association of America, the series covered a period of three days, September 17-19, and had as its object the determination of the relative merits of several gas testing methods.

One of the methods under consideration, and the one which was given the most thorough study, was the rectified 30 lb.-32°F. charcoal test which has been proposed by the California Natural Gasoline association as a standard method for determining the gasoline content of gases in California gelds. Involving a distillation procedure of 30 lbs. pressure, the equipment of this method is somewhat more elaborate than the apparatus commonly used for testing in the Mid-Continent. In the latter area, compression testing, charcoal testing at 0 lbs.-32°F. and fractional analysis are the accepted methods for settlement tests, the first two methods being the most widely used.

Though there is no intimation as yet that the proposed California method may be extended to Mid-Continent operations, it was felt that a thorough study of its application to the latter area was essential. There is little doubt

as to the accuracy of the method though the advisability of its adoption in the southwest is subject to question for several reasons. The very nature of the apparatus itself makes it a laboratory method which, in view of the widespread operations of the Mid-Continent, would be a physical handicap unless a very large number of expensive units were purchased for installation in each individual plant. The centralized operations of the west coast eliminate this necessity and central laboratories can serve a number of plants. The introduction of a new test method might also seriously disturb existing contractural relations.

With these several factors in mind, the Gas Testing Committee of the N. G. A., under direction of Norris Plank, Shell Petroleum Corporation, chairman, planned the field meeting of last week. An average of eight tests were run with each method, the gas samples used being taken simultaneously by different company representatives from a common manifold at lease settings. The results of the series are now being tabulated and a complete report will be prepared by the committee. Supplementing these practical field tests, the committee will attack the problem from another and more technical side by checking the methods against plant efficiency and with by-product fractions.

Companies participating in the tests, either directly or indirectly, include: Shell Petroleum Corporation, Lone Star Gas Company, Empire Oil & Refining Company, Continental Oil Company, Hanlon-Buchanan, Inc., Skelly Oil Company, Peoples Ice & Fuel Company, Carter Oil Company and Gypsy Oil Company. Completely equipped compression test cars were furnished by Shell Petroleum Corporation, Empire Oil & Refining Company and Phillips Petroleum Company, the latter company also making available its laboratory facilities at one of its Burbank plants where charcoal testing apparatus was set up and distillation tests were run.

Maps Show Refinery Districts, Companies

MAPS in color, showing not only the refinery districts of the United States, but also the cities in which refineries are located and the names of operating companies, have been published by J. H. H. Muirhead, of 230 West 108th Street, New York.

A large map, 44 by 56 inches in size, reveals all refinery districts, with administrative sub-districts, while four sectional maps present detailed information, including shipping points and post offices, concerning the Texas-Oklahoma-Kansas, Ohio-Pennsylvania, Montana-Wyoming and Pacific Coast refining districts. The maps are printed on heavy paper, suitable for framing.

Treatise on Motor Fuel Manufacture and Uses

THE modern high-speed, high-efficiency internal combustion engine evidently has come to stay, but its fueling has created a variety of problems still far from solution, according to the foreword of "The Principles of Motor Fuel Preparation and Application," comprising two volumes with a total of 1,081 pages now in the library of the American Petroleum Institute. The authors are Alfred W. Nash, professor of petroleum technology at the University of Birmingham, England, and Donald A. Howes, of Anglo-Persion Oil Company. The work was published by John Wiley & Sons, New York, and is available at $8 per volume through the Book Department, Gulf Publishing Company, Box 2811, Houston, Texas.

Volume 1 covers production of motor fuels by distillation and cracking of petroleum, by extraction from natural gas, and by hydrogenation, as well as methods of refining these fuels. Included are chapters on benzol, alcohol, and synthetic fuels. Volume II deals with the properties of motor fuels and methods of test, with particular reference to IPT and ASTM methods. Included are studies of sulfur, gum, and knock ratings, with chapters on fuel volatility, aviation fuels, fuel specifications, internal combustion engines, automotive Diesel engines, and Diesel fuels.

While fundamentally a particularly complete treatise for the technologist, the average oil man, and even the lay reader, will find interesting this revelation of the vast amount of study and work involved in the seemingly simple task of maintaining an adequate supply of motor fuel in the roadside gasoline pump. The authors give full recognition to changing needs, ideas, and tests, and even consider future trends. They have been unusually generous in making extensive references to other studies, and, all in all, have made a real and enduring contribution to man's knowledge of motor fuels.

Cracking Art Reviewed

"THE Cracking Art in 1934," by Gustav Egloff and Emma E. Crandal, is being distributed by Universal Oil Products Company, 310 South Michigan Ave., Chicago. This continuation annual reviewing of the developments in cracking, covers publications from December 1, 1933, to January 1, 1935. It is designated as Booklet No. 165. This annual correlation of engineering and technical data pertinent to the cracking art is a valuable aid to those engaged in such work. In this edition the authors cover the status of cracking, economics of cracking, cracking outside the United States, the cracking reaction, liquid vapor phase cracking, vapor-phase cracking, combination liquid-vapor and vapor-phase cracking, cracking with oxidation, electrical cracking, combination of operation, combination cracking and treating, treating cracked products, by-products of cracking, cracking equipment and reviews of cracking.

Some of the gas testing experts of Mid-Continent oil companies who took part in the N.G.A.A. series of tests. Kneeling are: L. H. Davies, Empire Oil & Refining Company; D. C. Sears, Gypsy Oil Company; Stanley McAnelly, Lone Star Gas Company; P. E. Rawlinson, Carter Oil Company, and H. A. Marshall, Gypsy Oil Company. Standing are: W. F. Lowe, secretary, Natural Gasoline Association of America; E. Love, Gypsy Oil Company; H. L. Oder, Empire Oil & Refining Company; Frank Whayman, Shell Petroleum Corporation; W. T. Kendall, Carter Oil Company; G. E. Felton and J. A. Schultz, Phillips Petroleum Company, and Norris Plank, Shell Petroleum Corporation.

"Inspection of Oil Refinery Equipment" Reprinted

THE important series of articles recently completed in THE REFINER dealing with "Inspection of Oil Refinery Equipment" has been reprinted in book form and is offered, in limited numbers, to those desiring this valuable work at $1.00 per copy. Copies can be secured from the Book Department, The Gulf Publishing Company, Box 2811, Houston, Texas.

This highly valuable work was prepared for publication exclusively in THE REFINER by Franklin L. Newcomb, supervising engineer, safety inspection division, general engineering department, Standard Oil Development Company. For many years Mr. Newcomb has been in active charge of all inspection work done for Standard Oil Company of New Jersey and its subsidiaries throughout the world, and his close contact with inspection work and developments in various phases of such work, makes him especially fitted to treat this subject in a comprehensive and understandable manner. The series of articles met with excellent response, which in turn, prompted their reprinting in book form. The instructive work deals with the following subjects: Scope of Inspection, equipment requiring inspection, frequency of inspection, parts of equipment requiring inspection, most serious corrosion, organization of inspection forces, methods of conducting inspections, various types of vessels, furnace tubes and header boxes, furnaces and fire boxes, care of instruments and gauges, maintenance and testing of safety valves, inspection of fire protection facilities, general safety features and housekeeping, tool required, records and forms required, limits for discarding equipment of various types. All of the original photographs, drawings, graphs, and tables are reproduced in the reprinted book. It will prove a valuable tool to those engaged in or interested in the care of, maintenance, and renewal of oil refinery processing facilities.

Standards Approved as Tentative by A. S. T. M.

ON the recommendation of a number of A. S. T. M. standing committees, Committee E-10 on Standards at its meeting on August 22 approved for publication as tentative 28 new proposed standards, approved revisions in 14 existing tentative specifications and accepted for publication as tentative revisions in several standards.

Including the actions taken at the meeting, A. S. T. M. now has a total of 790 specifications, test methods and definitions of which 505 have been formally adopted as standards, while 285 are tentative. A year ago the total figure was 728.

Recommendations on new standards were submitted by committees functioning in the following fields: steel, iron-chromium-nickel and related alloys, copper and copper alloys, cement, hollow masonry building units, paints, petroleum products, road and paving materials, textile materials, methods of testing.

Recommendations of Committee D-2 on Petroleum Products and Lubricants—The A. S. T. M. Tentative Method of Test for Vapor Pressure of Natural Gasoline (Reid Method) (D 323-32 T) was developed for natural gasoline but has been widely used for motor and aviation gasoline. The committee has developed a new tentative method of test for vapor pressure of motor and aviation gasoline which was approved by Committee E-10 as an A. S. T. M. tentative standard. It embodies a modification of the procedure for natural gasoline to improve reproducibility for motor and aviation gasoline. A note indicates that results can be obtained by the method with gasolines of 28 pound vapor pressure or less. Probable exceptions are gasolines of somewhat lower vapor pressure containing appreciable quantities of dissolved gases. A tentative revision was accepted for publication in the Standard Method of Test for Gravity of Petroleum and Petroleum Products by Means of the Hydrometer (D 287-33) which includes a modification of the requirements for the calibration of specific gravity hydrometers to bring them in line with usual commercial practice and it also includes a clarification of the method of testing volatile materials. The revision of the Tentative Definitions of Terms Relating to Petroleum (D 288-31 T) which was accepted includes a slight modification of the definition of fuel oil and an editorial rearrangement.

Proposed Standards Developed by Committee D-4 on Road and Paving Materials—On the recommendation of Committee D-4 on Road and Paving Materials nine tentative methods of test for soils were accepted for publication as tentative. These cover the following:

Surveying and Sampling.
Preparation for Test.
Mechanical Analysis.

Determination of: Liquid limit, plastic limit, plasticity index, centrifuge moisture equivalent, shrinkage factors, field moisture equivalent.

The methods have been developed as a result of extensive research extending over a long period of time, and a general agreement has been reached by those interested in soil testing that these methods are satisfactory for the purpose they are intended to serve. There is considerable demand for an exact description of the methods so that in so far as possible the results of individual laboratories may not be out of line owing to variations followed in connection with these methods.

Minerals Year Book

MINERALS yearbook, 1935, a 75-chapter, 1200-page book, in blue cloth binding, giving complete production statistics of all mineral commodities, can be supplied about September 30 at $2 a copy, by the Superintendent of Documents, Government Printing Office, Washington, D. C., to whom remittance should be made.

Past editions of the book have been exhausted promptly on publication, and requests for the 1935 volume will be filled in the order in which they are received.

Helium Research At Amarillo

PLANS for future activities of the research laboratory at the Amarillo, Texas, Helium Plant have been announced by John W. Finch, Director of the Bureau of Mines, Department of the Interior. The laboratory staff, which in the past has been concerned largely with work relating to production and conservation of helium, now will direct its efforts toward studies of technical problems involved in production and utilization of petroleum and natural gas. The Amarillo laboratory is one of the best equipped in the country for research on properties of gases at low temperatures, and additional facilities will be provided for the petroleum studies now being initiated.

The Bureau of Mines has been conducting research studies dealing with oil and natural gas through its Petroleum Experiment Station at Bartlesville, Oklahoma, and field offices at Dallas, Texas, and San Francisco, California. These include engineering and chemical studies relating to production, transportation and refining of petroleum, natural gas and their products. Such work is being broadened with initiation of petroleum research at the Amarillo laboratory and the reopening of an experiment station at Laramie, Wyoming, which will deal with problems in refining and production in the Rocky Mountain area.

In the Bureau's studies relating to oil production emphasis is being laid on the energy associated with petroleum fluids in their natural reservoirs, or producing formations, and the efficient utilization of that energy in obtaining the maximum recovery. The laboratory at Amarillo will take part in that phase of the Bureau's research by making studies of physical and thermal properties of petroleum mixtures that have influence on their flow through the producing sands and in wells, using specialized experience and technique developed in the research that has done so much to improve methods and reduce costs of extracting helium from natural gas.

Also the activities of the research group at Amarillo will include special studies of the causes and prevention of freezing in high-pressure natural gas pipe lines, often experienced at temperatures many degrees above the normal freezing point of water. This work will be closely correlated with investigations of flow of natural gas through pipe lines, which have been under way at Bartlesville.

The laboratory at Amarillo and field studies conducted from it will be especially beneficial to oil operators in the Texas Panhandle, West Texas and New Mexico districts.

The petroleum research activities at Amarillo, as well as the continued operation of the government-owned helium plant and 50,000 acres of natural gas properties, will be under the general direction of R. A. Cattell, chief engineer of the Bureau's Petroleum and Natural Gas Division, headquartered in Washington, D. C. C. W. Seibel, supervising engineer of the helium plant, will be in administrative charge at Amarillo, and several petroleum technicians will be added to his staff to aid in the petroleum research centered there.

Fuel Consumption at Refineries in 1934[1]

By G. R. Hopkins[2]

THE average quantity of heat needed to refine a barrel of crude oil in 1934 was 638,000 B.t.u., or about as much heat energy as contained in five gallons of fuel oil. Although the total heat utilized in 1934 was slightly above 1933, crude runs to stills increased four percent, hence the average requirement per barrel declined from 660,000 B.t.u. in 1933 to 638,000 B.t.u. in 1934. The average for 1934 constitutes a new record for firing efficiency, being just under the previous low of 1929.

Heat consumption at refineries depends on many factors, of which the trends in yields of gasoline and lubricating oils are probably most important. The yield of gasoline is indicative of activity at cracking plants, which type of plant utilizes more than the average amount of heat per gallon of product. The yield of lubricating oils is indicative of the extent to which crude oil is refined; that is, it takes considerably more heat to refine a barrel of crude through lubricating oils than it does to separate only gasoline and kerosene. The yield of gasoline decreased from 43.7 percent in 1933 to 43.4 percent in 1934; on the other hand, the yield of gas oil and fuel oil increased. Although the yield of lubricating oils increased slightly in 1934 the theoretical increase in fuel requirements probably was offset by technical improvements, such as solvent refining.

Although no outstanding technical developments of a fuel-saving nature were made in 1934, some progress undoubtedly was recorded. Heat exchangers, an effective fuel-saving device, were enlarged, and some refiners now take off several cuts before the crude reaches the pipe stills. The total capacity of pipe stills increased 2.5 percent in 1934, and many of the less efficient shell stills were torn out.

The year 1934 was important in fuel consumption at refineries as it marked the definite reversal of several trends which had been evidenced since the first survey was made in 1925. Prior to 1934 the principal trends had been declines in the use of coal and natural gas and the purchased fuels and a corresponding increase in the use of refinery or still gas. In 1934 more coal and natural gas but less refinery gas was used, indicating a growing realization that sometimes it is poor economy to be too self-sufficient.

Refinery Fuels

Oil.—The consumption of oil as refinery fuel continued its slow decline in 1934, when 33,163,000 barrels was burned compared with 33,292,000 barrels in 1933. Oil supplied 34.8 percent of the total heat units generated at refineries in 1934 compared with 35.1 percent in 1933 and 36.8 percent in 1932. The change in the status of fuel oil as refinery fuel in 1934 was too slight to permit drawing definite reasons for the decline. Practically all of the large plants are equipped to burn gas as well as oil, hence competitive prices are an important factor in determining which fuels will be utilized. Although fuel oil prices in 1934 were not maintained at the levels reached in the early days of the code, the average for 1934 was higher than for 1933. This stiffening in fuel oil prices probably caused some refiners to turn to other fuels. The tendency to produce less unsalable fuel oils of the nature of slops and sludges may have been a factor.

Acid Sludge.—The consumption of acid sludge as refinery fuel declined both in 1933 and 1934, although the art of burning sludges was undoubtedly perfected. This anomaly probably resulted from the fact that technical improvements, for example, solvent refining, has restricted the supply of sludge. The total consumption of acid sludge in 1934 was 4,702,000 barrels, compared with 4,990,000 barrels in 1933.

Coal.—The increase in coal consumption as refinery fuel in 1933 was shown to be more than a flash in the pan in 1934, when consumption again increased. The total used in 1934 was 1,189,000 short tons, compared with 1,069,000 short tons in 1933. These two successive increases in coal consumption substantiate the contention that oil and refinery gas are too valuable to use as refinery fuel.

Natural Gas.—The use of natural gas as refinery fuel, which showed indications of reversing its downward trend in 1933, scored a definite comeback in 1934, when consumption was 79,965,000,000 cubic feet, or 21 percent above 1933. In 1934 natural gas supplied 14.7 percent of the total heat units utilized at refineries, compared with a high of 21.7 percent in 1927.

Still Gas.—The steady increase in the consumption of still gas between 1925, the year of the first survey, and 1933 has been an outstanding feature of fuel con-

[1] Reprinted from U. S. Bureau of Mines Report of Investigations 3281.

[2] Acting chief economist, Petroleum Economics Division, U. S. Bureau of Mines.

Safe Motors for Dangerous Places

NO buildings and no fire walls are needed when Allis-Chalmers explosion-proof motors are used for driving pumps and other oil field and refinery equipment.

This type of motor safely resists internal explosions and is approved by the Underwriters' Laboratories for use in explosive atmospheres. It is a proven, successful, totally-enclosed, fan-cooled, squirrel-cage type explosion-proof motor ... with cast steel stator frame, specially insulated windings, indestructible rotor, combined end-closure and bearing housing ... embodying superior mechanical strength and positive sealing to assure safety.

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Now furnace outlet temperature can be controlled with almost uncanny precision by the

Taylor "DUBL-RESPONSE" CONTROL SYSTEM

IF YOU ever had trouble with close, accurate control of furnace outlet temperature, read this story.

In the Mid-Continent field there is a refinery with these furnace conditions:

The through-put was changed from 2900 to 2300 barrels.

The inlet temperature increased from 100° to 450° F.

The gas supply pressure for the furnace varied from 22 pounds to 35 pounds daily.

The content of the gas supply varied from 1050 to 1800 B. T. U.

Yet the furnace outlet temperature was maintained steadily at about 710° F.

But there was no constant control of temperature until a Taylor "Dubl-Response" Control System was installed on that furnace.

Here is another example of the almost unbelievable ability of this proved Taylor Control to solve problems that have bothered oil men for many years.

Before today it was a question of running around and watching refinery operations and temperatures. This took hours of time and effort that are now unnecessary. Where the Taylor "Dubl-Response" operates, the stillmen know this running around is a waste of time. The "Dubl-Response" Control works automatically—precisely—positively—without supervision.

The pictures show the main instruments in the system. The chart shows the result of this remarkable control. A Taylor Representative will show you how to adapt the "Dubl-Response" to your problems.

This System has everything an automatic controller should have for an oil refinery:

Full independent range sensitivity adjustment, independent of dampening; full range reset independent adjustment, independent of sensitivity; precision valve action; adaptability to your conditions without disturbing other set-ups in connection with fractionating towers.

You will save money, time, worry, trouble if you write for full information today. The Taylor "Dubl-Response" is a 1940 answer to your 1935 needs. Write Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada. Manufacturers in Great Britain —Short & Mason, Ltd., London.

SEND FOR BULLETIN 37 R, which tells about all types of controllers and the reasons why the "Dubl-Response" was developed for the oil industry. **WRITE TODAY FOR YOUR COPY.**

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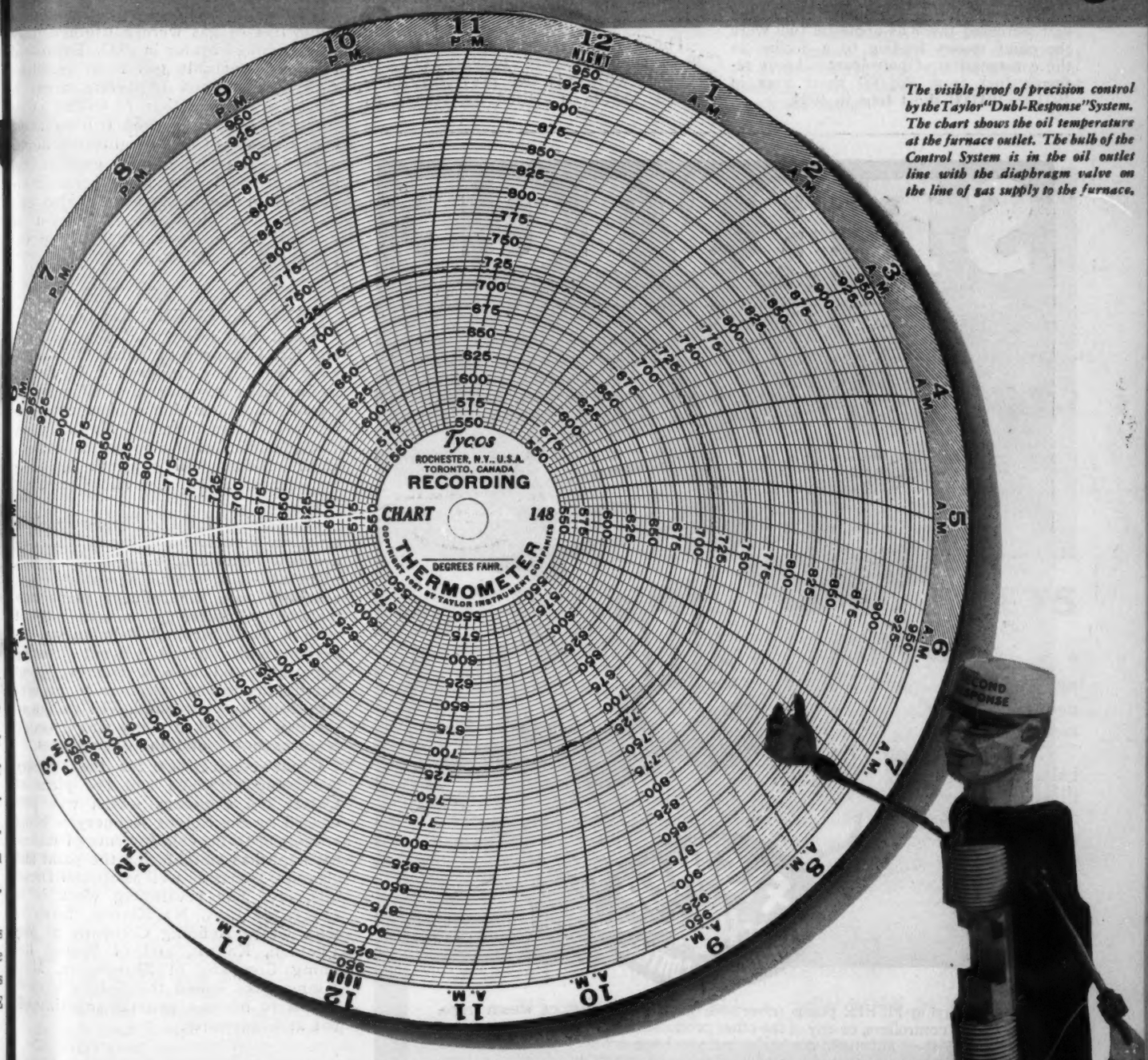

The visible proof of precision control by the Taylor "Dubl-Response" System. The chart shows the oil temperature at the furnace outlet. The bulb of the Control System is in the oil outlet line with the diaphragm valve on the line of gas supply to the furnace.

(Left) The Taylor "Fulscope" Controller, latest development in the instrument field with every advantage and refinement you can think of. (Right) The Taylor Dubl-Response Control Unit, used with the Fulscope to take care of load changes and other abnormal variables. Together they make the Taylor "Dubl-Response" System.

sumption at refineries. Accordingly, the decrease in consumption from 172,085,000,000 cubic feet in 1933 to 164,741,000,000 feet in 1934 is of considerable significance. This decrease cannot be attributed to a lower output as total production in 1934 was only slightly below 1933. The most plausible explanation is that increasing amounts of still gas were diverted for manufacture into other products, chiefly gasoline. Still gas supplied 40.4 percent of the total heat units in 1934 and remained the leading fuel.

Petroleum Coke.—Declining production and increased favor as domestic fuel were the chief causes leading to a decline in the consumption of petroleum coke as refinery fuel from 263,000 short tons in 1933 to 194,000 short tons in 1934.

Gas Reserves Estimated at 75 Trillion Cubic Feet

GEOLOGY of the most important known occurrences of natural gas on the North American Continent, methods of estimating natural gas reserves, and a resume of the natural gas industry are presented in a 1,228-page volume, "Geology of Natural Gas," published by the American Association of Petroleum Geologists, Tulsa.

The book, a symposium presenting 38 technical papers prepared by 47 authors, with only two previously published, has been edited by Henry A. Ley as a record of present geologic knowledge of natural gas.

Concerning the future of natural gas supplies, it is stated in the foreword that there are no known geologic reasons why recent high levels of metered natural gas production cannot be maintained for many years. The present combined daily open flow capacity of commercial natural gas wells in the important and proved producing areas of the United States is said to exceed 55 billion cubic feet. About 4278 billion cubic feet of gas were consumed daily in the United States in 1933. Estimated future recoverable gas from commercially proved and important areas is placed at not less than 75 trillion cubic feet, of which about 34 trillion cubic feet are said to be in California alone.

Important economic, engineering, and statistical data have been incorporated in the book, as are also two papers describing the estimation of natural gas reserves prepared by experienced specialists.

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ANNOUNCEMENT has been made that two officers of the Bell Oil and Gas Company of Tulsa, Oklahoma, have been elected officers of the Solvex Refineries, Incorporated of Gladewater, Texas. I. Arthur Anson, becomes secretary and treasurer, and M. L. Freese, vice-president of the Solvex Refineries. Both officers will continue as vice-presidents of Bell Oil and Gas Company.

Foundation for the Dubbs cracking unit has been laid and heavy materials are now being shipped into the Solvex plant at Gladewater. In addition to a cracking unit, the refinery plans now include a complete vapor recovery plant with a stabilizer and debutanizer, together with special solvent treating apparatus and also a treating plant having the use of inhibitor to prevent gum-forming compound. The design of the unit is novel in many ways, having features not found in other plants.

Crude connections for the refinery are being arranged and the plant of Culver Oil Company which was purchased by the Solvex Refinery is being revamped to provide for cuts of technical naphthas suitable for the paint and cleaning trades as well as special Diesel oils, etc. The revamping work is in charge of J. A. MacKinnon, formerly with Globe Refining Company at McPherson, Kansas, and of Sparco Refining Company at Shreveport. MacKinnon has joined the Solvex organization to become general superintendent at Gladewater.

THE election last month of Philip H. Patchin to the board of directors of Standard Oil Company of California followed an extensive career in journalism, public relations and diplomacy, and long service in the oil industry. As a New York newspaperman and war correspondent, Mr. Patchin saw service in many parts of the world. During the earlier part of the World War he was stationed in London, the focal point of news from the allied front. Upon the entrance of

PHILIP H. PATCHIN

the United States into the war he returned to this country to serve throughout the remainder of the conflict as Public Relations Representative of the State Department, and attended the peace conference as a secretary of the American peace mission. After coming to the Coast he was again summoned to Washington in 1922 to take charge of the Public Relations of the American Delegation at the Disarmament Conference. Since 1919 Mr. Patchin has filled the position of assistant to President K. R. Kingsbury of Standard Oil Company of California. His services in this capacity led to his appointment as a director of the company.

T. B. HUDSON, president of The Polymerization Process Corporation, announces that Hy Byrd of New York, assistant secretary of Phillips Petroleum Company, has been elected secretary and treasurer of the new corporation. The offices of the new corporation have been established at 15 Exchange Place, Jersey City, N. J.

The polymerization process which is being licensed by The M. W. Kellogg Company is meeting with a great deal of interest throughout the petroleum industry and applications have been received by the new corporation for licenses and quotations on plants from over 15 of the large refinery companies of this country, as well as several from abroad, involving large expenditures. The product of the polymerization operation is an exceptionally high quality, high octane, motor fuel and offers great opportunity to the industry in raising the standard of motor fuel now being offered to the public.

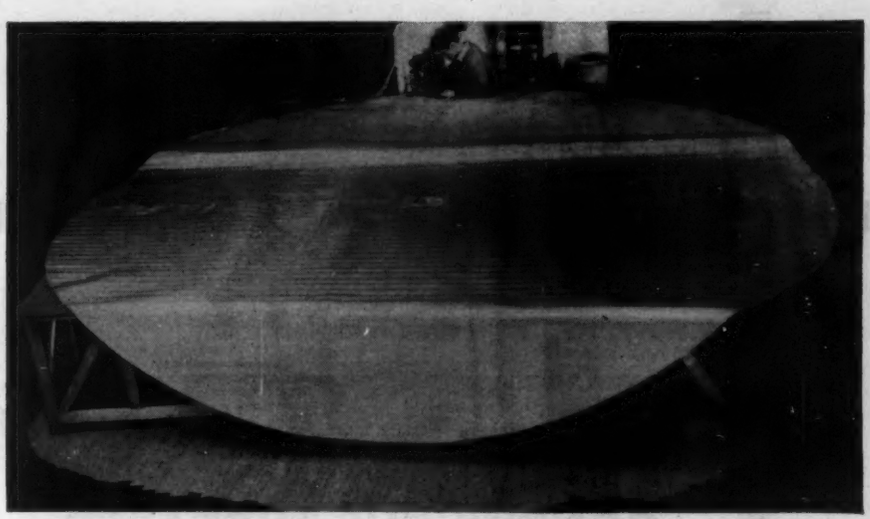
ANALYSIS and Handling of Gases. *Augustus H. Gill.* 71 pages. Edward Brothers, Inc., Ann Arbor, Michigan, 1935. Price, $2, with discount of 20 percent for orders of 10 or more.

This book embodies in brief form not only the usual methods of gas analysis, but also methods of qualitative analysis and data on the properties of gases, including their physiological action. It is intended for those who, as stated in the Preface, have enough chemical sense or "gumption" to set up the different pieces of apparatus without minute directions. However, very little knowledge of chemistry is assumed, the volume changes in the explosion of methane and hydrogen, for example, being shown by elementary diagrams. A chapter is devoted to the care of cylinders of compressed gases and the precautions to be used in handling these cylinders. The distinction between sewer gas as combustible gas which has leaked into sewers, and sewage gas as one resulting from the decomposition of sewage is new to the writer but seems justified.

Professor Gill has compressed into this little volume many observations resulting from his long experience. The book is put out in photolithographed form, which gives it somewhat the appearance of being a preliminary edition. It is, however, clearly printed and is easy to read. Only minor misprints have been noted.

A. H. WHITE, in *Industrial and Engineering Chemistry.*

JAMES McKEE, for many years in charge of the grease production department of the Sun Oil Company's Marcus Hook, Pennsylvania refinery, died September 15 at the age of 67. His death occurred following an operation. He was widely known in the refining industry as a grease technologist and he was prominent in many research activities identified with the trade.



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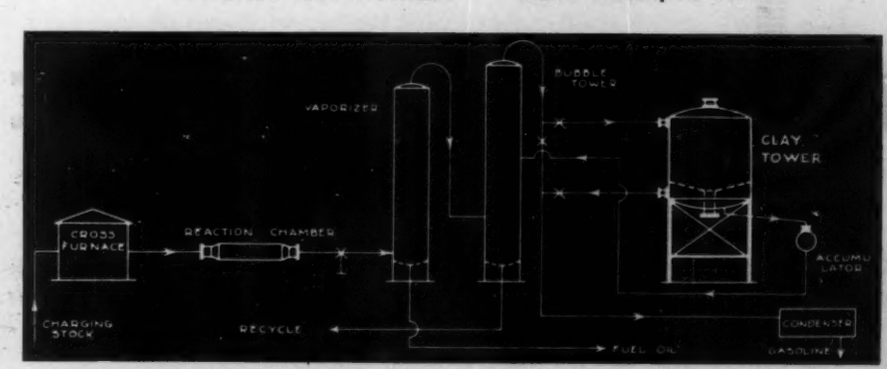

Plan Expansion of Vocational Classes

EXTENSION into Kansas, Louisiana, California and Arkansas of evening vocational training courses for workers in the petroleum industry is being considered by the American Petroleum Institute's Topical Committee on Vocational Training. Some 5000 workers participated in vocational studies sponsored jointly by the state governments of Texas and Oklahoma, the federal government, and the petroleum industry in the fiscal year ended June 30 last, and the committee has been informed that demand for extension and expansion of the work is growing.

▼ PLANT ACTIVITIES ▼

Improvements: Standard Oil Company of California announces the construction of improvements at Richmond refinery on San Francisco Bay which will cost approximately $1,800,000. Work upon the plans and specifications for the proposed improvements has been initiated. When these are finished, which will be some time hence, actual construction will be started by Stone and Webster Engineering Corporation, which will employ between four and five hundred men. The principal improvements will be construction of a modern steam power plant to replace antiquated equipment.

Refinery: "Aquila" S. A. Tecnico-Industriale, Trieste, Italy, has been granted permit to construct a new 5,000-barrel refinery which will include lubricating oil production facilities.

Refinery: Azienda Commerciale Italiana Olii Minerali, S. A. Tripoli, has announced plans for construction of a new 1,000-barrel topping plant.

Improvements: Azienda Generale Italiana Petroli (A. G. I. P.) Mestri, Italy, is installing new distillation equipment and cracking unit.

Cracking Unit: Compania Espanola de Petroles, S. A. Teneriffe, Canary Island, is enlarging the original plant through installation of a new cracking unit.

Solvent Units: Duetsche Vacuum Oel A. G. Bremen, Germany, is building a new solvent refining system and a new solvent dewaxing process.

Cracking: De Bataafsche Petroleum Maatschappij, Rotterdam, Holland, is reported planning installation of 10,000-barrel capacity cracking unit and a converting asphalt refinery to produce other products.

Enlarge: De Bataafsche Petroleum Maatschappij at Balikpanan, Borneo, has enlarged through addition of new crude distillation facilities.

Enlarge: The Egyptian Government, Department of Mines, Suez, Egypt, is reported completing a new distillation unit.

Operating: Kermanshah Petroleum Company (Anglo Iranian Oil Company), started operating new refinery at Kermanshah, Iran, early in October.

Enlarge: Hercules Gasoline Company, Kilgore, Texas, enlarging capacity of natural gasoline plant and laying an additional 30 miles of gas gathering lines.

Enlarge: Lago Oil & Transport Company Ltd. (Standard Oil Company of New Jersey) is completing installation of new topping equipment to increase capacity to 160,000 barrels daily.

Refinery: South Manchuria Railway Company, Dairen, Manchuria, is now building a new refinery, including cracking facilities.

Refinery: Vacuum Oil Company, S. A. I.—near Naples, Italy, has been granted permit to build complete refinery and has let contracts for 4,200-barrel distillation and cracking facilities, also lubricating oil plant.

Distillation: Sweet Oil Company, Wyman, Michigan, is building 1,200-barrel distillation unit. Contract to Roy J. Miller Petroleum Engineers.

Polymerization: Pan-American Refining Corporation, Texas City, Texas, has awarded contract to Foster Wheeler Corporation for construction of a Universal catalytic polymerization process unit to cost approximately $1,000,000 and to produce 2,000 barrels of "Poly" gasoline daily.

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HOUSTON, TEXAS

Enlarge: Gregg-Tex Gasoline Corporation, Longview, Texas, is doubling capacity of natural gasoline plant to produce about 50,000 gallons of gasoline daily. Company will tie to 650 additional wells. Estimated cost is $250,000. Contract to Petroleum Engineering Inc. associated with Arthur G. McKee & Company.

Enlarge: Peppers Gasoline Company, Oklahoma City, Oklahoma, is to double capacity of natural gasoline plant in the Oklahoma City field. Contract to Petroleum Engineering Inc. associated with Arthur G. McKee & Company. Work includes additional distillation unit, and extra cooling, stabilizing and heat exchange equipment.

Refinery: McCook Oil Company, Houston, has completed reconstruction of refinery recently taken under lease from the Southern Pacific Lines, and is operating for the production of lubricating oils and fuels. The company was organized recently by R. C. Cook, formerly vice-president of American Petroleum Company Houston, and H. L. McMenemy, formerly in charge of refinery operations for Chalmette Petroleum Corporation, New Orleans.

Purchase: The Southland Refining Company, Olney, Texas, has purchased the Archer Refining Company refinery formerly owned by White and Duncan of Wichita Falls. The plant is located between Olney and Megagel, two miles south of the Swastika field.

Chemical Plant: Carbide & Carbon Chemicals Corporation, New York, has completed large plant at Whiting, Indiana, where it is producing both ethyl alcohol and acetone and preparing for production of additional synthetic organic chemicals. The plant is located close to Standard Oil Company (Indiana) refinery and uses refinery gases from this plant. Rumors and reports are afloat in oil and equipment circles at Houston that the company is planning establishment of a similar synthetic chemicals plant probably at Baytown near the large plant of Humble Oil & Refining Company, to cost between five and ten million dollars.

Refinery: Crystal Refining Company, Carson City, Michigan, is building a new 1,000-barrel skimming plant. Del Fortney, president, M. A. Hagerman, secretary and treasurer. E. G. Guy, consulting engineer, is supervising construction.

Gasoline Plant: British-American Oil Company, Toronto, Ontario, Canada, which recently entered the south Turner Valley, Alberta, field, is reported planning construction of a natural gasoline plant in that area, and is also reported studying plans for a refinery at Calgary.

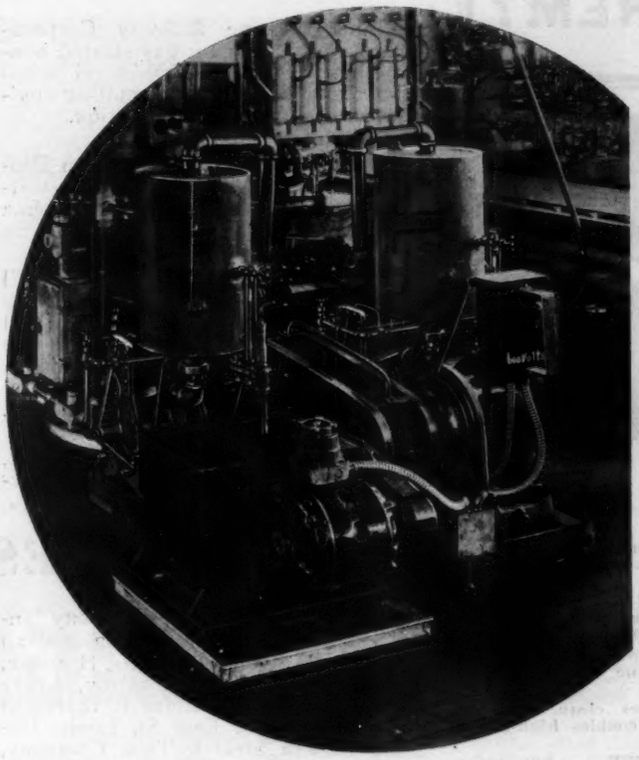
Refinery: The Wood-Callahan, National Oil Company and Eugene Starr interests operating in the Mountain View field, near Bakersfield, California, are erecting a 5,000-barrel refinery on the Wells lease in the field.

Building: Solvex Refineries, Inc., Gladewater, Texas, now building a combination skimming and cracking plant of Dubbs type, have purchased the Culver Oil Company plant and is revamping it for the production of special naphthas and Diesel oils. J. A. MacKinnon is general superintendent.

Refinery: Russell Refining Company, four miles west of Russell, Kansas, is building a 1,000-barrel skimming plant, using mostly material purchased at a shut down plant at Chanute, Kansas. Company incorporated for $25,000. W. F. Michell, formerly of Dallas, Texas, is superintendent and one of the incorporators. Others mentioned in state charter were Robert Sohlberg, McPherson, Kansas, Max H. Farmer, Dallas, Texas; Charles Lischesky and Senator Coe Russell of Great Bend, Kansas.

Refinery: Anarene Oil & Refining Company, Olney, Texas, is completing a 500-barrell skimming plant to use local crude. Ralph McQuigg is president, C. H. Petty superintendent.

Improvements: Rodessa Oil & Refining Corporation, recently organized, has purchased Crystal Oil Company's Cedar Grove (Shreveport, Louisiana) refinery and will recondition at cost of $50,000 to resume operations. The new company was organized by M. J. Grogan, who is president, B. P. Crittenden, who is vice-president, W. F. Kostelka, vice-president and sales manager and J. E. Marshall, secretary-treasurer.



Kinney Vacuum Pumps

How much does a vacuum pump *really* cost?

The Engineering Dept. of a certain company requisitioned a Kinney High Vacuum Pump. The Purchasing Dept. objected as the Kinney price was $2080 and the other make but $1250.

The answer was as follows: The Kinney 500 cu. ft. displacement pump at 28" vacuum was guaranteed 61% efficient—an actual delivery of 305 cu. ft. COST OF PUMP PER CU. FT. = $6.82.

The other make 500 cu. ft. pump had an estimated but not guaranteed efficiency at 28" of 10%—an actual delivery of 50 cu. ft. COST OF PUMP PER CU. FT. = $25.00.

In addition the Kinney required 20% less power—a substantially lower operating cost.

Subsequently this company has purchased $20,000 worth of Kinney Vacuum Pumps.

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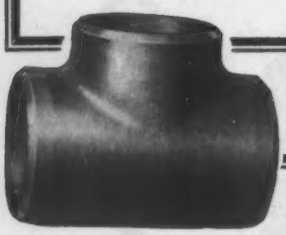

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Operating: Carrot River Oil Refineries, Ltd., Melfort, Saskatchewan, Canada, started operating 250-barrel skimming plant about the middle of September. The company is locally owned and the plant will run on East Texas crude for the present. N. E. Browett is superintendent of the refinery. All equipment, buildings, etc., were designed and erected by C. V. Humphreys, consulting engineer of Winnipeg, Manitoba, Canada.

Gasoline Plant: Lone Star Gas Company, Dallas, Texas, is building a $250,000 natural gasoline plant at Trinidad, Texas, on the company's gas line from Anderson County, Texas, fields to Dallas. Capacity reported 20,000 gallons daily. To be in operation January 1, 1936.

Refinery: Acme Refinery Corporation, Alma, Michigan, has started construction of a new 2,500-barrel skimming plant. E. G. Guy, consulting engineer, is supervising construction.

Refinery: Wolverine Petroleum Products Company, Alma, Michigan, started construction of new plant at Alma about the middle of September.

Operating: Bright Star Company, El Dorado, Arkansas, has taken over the old Kettle Creek plant south of El Dorado and started operating for the production of lubricating oil distillates, charging about 1,000 barrels of oil daily. Plant is financed by local capital.

Refinery: Deseronto Refineries, Itd., Deseronto, Ontario, Canada, R. D. Perry president and manager is reported planning a refinery to cost about $100,000.

Polymerization: Humble Oil & Refining Company, Baytown, Texas, early in September was reported starting operation of a new polymerization plant producing about 125 barrels per day. Reported cost $180,000.

Refinery: Park Refining Company, Cody, Wyoming, is building a small skimming plant north of Cody and east of The Texas Company's holding. D. D. Gibson of Thermopolis is in charge of local operations.

Enlarge: Lomita Gasoline Company, Mountain View plant, northern California, has added unit to increase capacity from 15,000 to 25,000 gallons per day.

Reforming: Shell Petroleum Corporation, Houston, in addition to other work recently completed and some recently announced, is adding to cracking capacity through addition of a Dubbs plant to operate as a reformer at 10,000 barrels capacity.

Modernization: Skelly Oil Company, Eldorado, Kansas, has completed revision of its cracking unit No. 9. The furnace was completely rebuilt, turnkey job, by Alcorn Combustion Company. The company itself revised the fractionating equipment. This involved cutting out all of the old bubble trays, completely cleaning the inside of the tower and installing new streamline bubble trays made by Alco Products, Inc. Industrial Engineering Service of Tulsa supervised the latter work.

▼ BUSINESS NOTES ▼

KOALT Engineering Company announces that it has established an office at 807 Sterling Building, Houston, in charge of J. H. Richardson, where the company will continue to represent Key Company of East St. Louis, Illinois; Timken Steel & Tube Company, Canton, Ohio, and Fahralloy Company of Harvey, Illinois.

TITUSVILLE Iron Works Company of Titusville, Pennsylvania, manufacturers of boilers, engines, and oil field equipment, has obtained the manufacturing and sales rights on the Master line of scrubbers and separators, except in the state of California.

The Master line is well known on the West Coast, and comprises: gas, and oil separators, steam scrubbers, gas scrubbers, oil scrubbers, oil and water separators, oil-gas-sand-water scrubbers, feed water heaters, and water heads.

GENERAL Refractories Company, Philadelphia, announce the appointment of The Chas. A. Strelinger Company, Detroit, Michigan, as dealer agents in the Detroit area. The company will carry a complete stock of refractories in addition to their well rounded line of industrial supplies.

JOHN W. Carpenter, for 16 years district sales manager in the Cleveland, Ohio, territory for the Otis Steel Company, has joined the organization of Republic Steel Corporation, as assistant manager of sales, Sheet and Strip Division. Carpenter, a graduate of Princeton University, served as first lieutenant in the Army during the World War and entered the steel industry immediately afterwards. He brings to his new connection a wide knowledge of the steel business with particular emphasis on flat rolled products.

SOLVAY Sales Corporation announces the opening of two new branch offices, one at Houston, in the Petroleum Building, the other at Charlotte, North Carolina, in the Johnston Building. These new branches have been established in the interest of better service to its customers in the South and Southwest. This expansion involves no change in the company's present distributing representation in these territories and customers' requirements will continue to be handled through present sources of supply as heretofore.

CARBONDALE Machine Corporation, Harrison, New Jersey, recently reorganized as a subsidiary of Worthington Pump and Machinery Corporation, to cover the manufacture and sale of all classes of refrigeration, ice manufacture and air conditioning equipment, has announced officers and directors as follows: H. C. Ramsey, president; H. A. Feldbush, vice-president; A. H. Baer, vice-president in charge of sales; A. L. Prentice, secretary and treasurer.

J. P. Distler has been appointed manager of sales, Wire Division, Republic Steel Corporation, with headquarters at the Grand Crossing plant in Chicago. He succeeds R. W. Hull whose duties as assistant manager of sales for all Republic products in the Chicago district will now receive his entire time.

Prior to his appointment with Republic Steel Corporation, Mr. Distler had been connected with Keystone Steel & Wire Company continuously since 1918. For the past five years he was general manager of sales for that organization, following 10 years of experience as assistant sales manager during which time the entire government, railroad and industrial business of the company was built under his supervision. For the past two years he has served on the commercial committee of the American Iron & Steel Institute.

THE Griscom-Russell Company, manufacturers of heat exchange equipment, announces the appointment of A. W. Burket as district manager, located at 20 North Wacker Drive, Chicago, from which point he will supervise direct sales and agency activities in the Chicago, St. Louis, Detroit, Milwaukee and adjacent territories. Burket, who until recently has been in business in Tulsa, Oklahoma, is well known in heat exchanger and similar equipment fields.

ALUMINUM Industries, Inc., of Cincinnati, manufacturers of Permite Products, has announced a new office, 1004 Petroleum Building, 616 South Michigan Avenue, Chicago. The office will be the headquarters for Permite sales representatives and sales engineers servicing the central states. The same announcement notes the acquisition of R. L. Corey, long connected with the automotive and industrial trade, as district sales representative for Indiana, Illinois, Wisconsin, Iowa, Missouri and Minnesota. N. R. Patterson, for the last year affiliated with Permite, as sales engineer, also will have his headquarters in the Chicago office.

PROMOTION of A. E. Heroux to the position of general manager of the Permite Paint Sales Division of Aluminum Industries, Inc., manufacturer of Permite Products, Cincinnati, Ohio, is announced by Donald McDonald, vice-president. Heroux, who has been associated with the company for three years, in the capacity of Detroit district manager of the paint division, succeeds A. B. Anderson, who recently resigned.

THE Babcock & Wilcox Tube Company, Beaver Falls, Pennsylvania, announces appointment of R. P. Kilsby to the managership of its western sales territory. He will have jurisdiction over all the districts covered by its offices located west of the Mississippi River and will make his headquarters at the company's Chicago office in the Marquette Building. He formerly was attached to the general sales office of the company at Beaver Falls.

THE board of directors of A. O. Smith Corporation, through Rae F. Bell, executive vice-president, have announced the election of Carl C. Joys, Jr., to the office of vice-president of the corporation. Joys has been connected with A. O. Smith Corporation since August 1, 1924, as manager of sales, and later in the capacity of director of sales of the oil and gas products division and all other products aside from the automotive division and has devoted his entire time to these lines. He will continue this work in his new position as vice-president. He has been a director of the corporation since October, 1927.

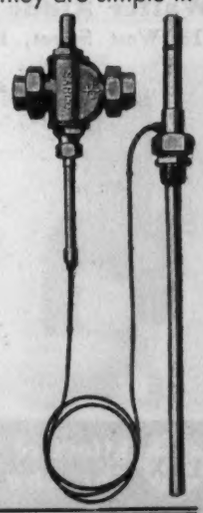
THE Kennedy Valve Manufacturing Company announces the appointment of William Godbey as its representative in Kansas, Nebraska, Western Missouri, and Southwest Iowa. He will handle the sales of Kennedy iron body and bronze valves, fire hydrants, malleable iron and bronze screwed fittings and cast iron flanged fittings and flanges in this territory and his headquarters will be in Kansas City, Missouri.

THE management of Felt Products Manufacturing Company announces the appointment of Joseph M. Bandish as director of sales of the metallic packing division of that firm. A veteran of the packing industry, Bandish brings to his new position a wealth of practical knowledge gained through years of intimate contact with actual packing problems. His reputation as an originator and designer of packings is well known throughout the industry. His new offices will be located in the Felt Products Building at 1508 Carroll Avenue, Chicago.

If anything goes wrong with the apparatus on a ship while at sea, it is impossible to ring up the manufacturer and get it fixed in a few hours. Consequently, it is important to install only equipment that has proved dependable.

It is a convincing tribute to the satisfactory performance and long life of Sarco Temperature Regulators to be selected for the Normandie—the greatest mass of steel and machinery ever to sail the sea.

Sarco Temperature Regulators are dependable because they are simple in construction and have nothing to get out of order. They have no troublesome stuffing boxes. The valve body cannot be distorted when installing. Valve seats will not stick and are easy to regrind when worn.



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Quick Test for Free Sulphur

THE usual doctor test for gasoline or test for mercaptans consists of adding doctor solution and then adding free sulfur to the gasoline and shaking the sample. If the test is positive it indicates the presence of mercaptans. In the present test the method is reversed. Mercaptans are added to the gasoline under inspection, and then doctor solution is added. If the test is positive it indicates the presence of free sulfur in the gasoline.

Method: To 6 cc. of sweetened gasoline add 3 cc. of doctor solution, and then add 3 drops of butyl mercaptan in mineral oil solution. Shake. Add 10 percent acetic acid solution. The mixture will turn cloudy at the first addition of acetic acid. Continue to add acid until the solution becomes clear. If a brown layer appears between the two liquid layers, the gasoline contains free sulfur and will be corrosive to the copper strip test. If the test is negative, then the gasoline should test O.K. to the copper strip. The butyl mercaptan solution is a one percent solution in mineral oil.

The test requires not more than two minutes to run, which is quite a time saving over the conventional copper strip methods, which usually requires about 15 minutes.

E. R. JONES,
Eldorado, Kansas.

Float Controls Pump Suction

IN order that a certain level may be obtained continuously in oil and water separating sumps, Pure Oil Company, Midland, Michigan, designed a float which accomplishes this without attention. A considerable amount of water is handled, which is contaminated slightly with waste oil. It is of course necessary to effect a separation of these liquids, not only so that the oil may be reclaimed, but to avoid pollution. The separating vats are made in the ordinary manner, but in the last receptacle, the clean water is removed by pumping. A large square float was made by welding light sheet metal in the box like form and size desired, with a stirrup connected to the top head.

The two walking beams are made of 1½-inch pipe, braced and mounted as shown in the illustration. The walking beams were connected to each other, at right angles, so the movement of the first caused by the lowering of the water level, raises the other, and as a result, a gate valve, which is attached to the end of the second walking beam, is closed, thereby shutting the line against the centrifugal pumps used to move the water. The threads were removed from the stem of the gate valve so the closing occurs easily. The assembly is designed so the travel of the gate valve permits continuous flow of water from the vats.

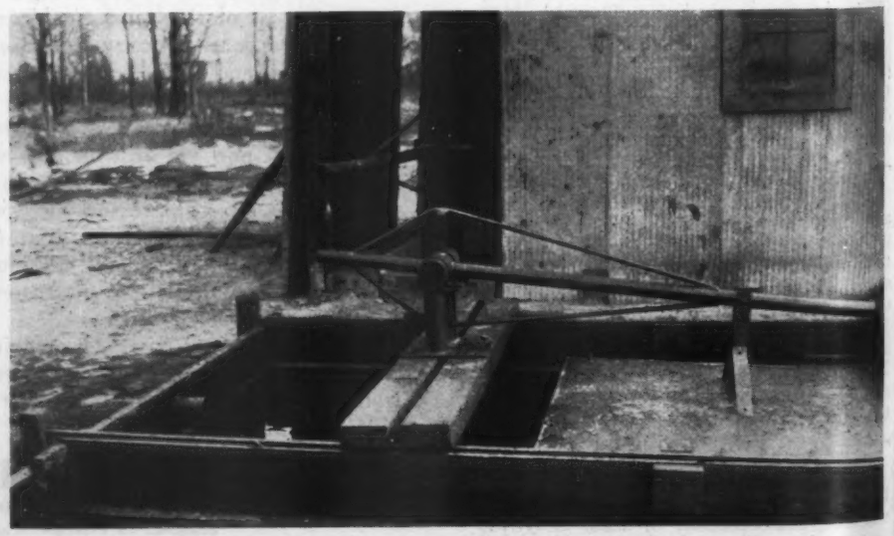
Distillation Apparatus

THIS concerns a distillation apparatus for control purposes in the manufacture of low boiling products such as propane.

The apparatus consists of a graduated cylinder placed partially inside of a stoppered glass cylinder. The graduated cylinder is fitted with a thermometer through a rubber stopper. The stopper has a slot cut in it to permit the escape of vapors that boil off the liquid. This cylinder has a small well in the bottom just large enough to hold the bulb of the thermometer. This is necessary in order that the bulb of the thermometer is covered until the end of the distillation.

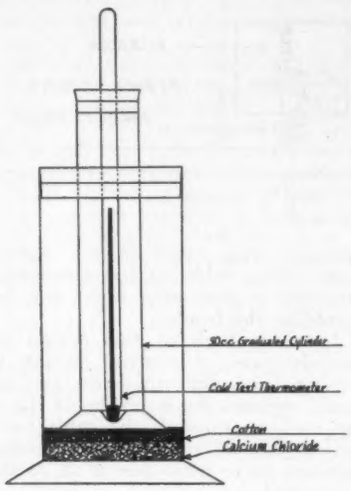
In the bottom of the outside container are a few pieces of calcium chloride covered with cotton. The calcium chloride keeps the inside of the jacket free from moisture which is necessary to keep frost from forming on the distillation cylinder. If frost collects it is impossible to read the thermometer and to see the liquid in the inner cylinder.

The inside cylinder is filled with the



Device designed to control flow of water pumped from the trap.

liquid to be distilled and the liquid discarded. This is to properly cool down the apparatus. The thermometer is also cooled down at the same time. The cylinder is again filled and the thermometer put in place. The apparatus is allowed to stand and as the liquid boils down the percentages boiled off can be read if desired. The rate of distillation usually is too slow when 90 percent has evaporated so the liquid is shaken with a whirling motion of the apparatus, not up and down. With a little practice check results can be obtained.



Control Apparatus for Manufacture of Low Boiling Hydrocarbons.

The apparatus is very useful for controlling the top temperature of the stabilizer when cutting propane out of the natural gasoline.

E. R. JONES,
Eldorado, Kansas.

Making Distillation Unit "Handier"

SEVERAL time saving devices have been added to the A.S.T.M. distillation unit shown in the drawing. An eye has been formed at the end of a welding rod; the rod bent at right angles about six inches from the eye, and the rod placed parallel to the regular ring-stand. Two couplings attach the rod to the stand, the coupling at the base of the rod being drilled only one half of its thickness to allow the rod to set in the coupling and still swing to the right or left. The other coupling is loosely drilled for the rod. A length of piano wire is passed through the eye in the rod and attached to the thermometer and to a nut which slides up and down on the rod. When the distillation is completed, the thermometer is lifted from the flask and is pulled up and to one side by the counter-weight. This plan, in addition to its apparent convenience, also saves the thermometers from breakage.

The gas service is brought up through the table into the bottom of the flame shield, while the gas control valve protrudes through the shield where it is handy. The rubber tube connections are out of the way. They may be covered to retard deterioration. The delivery end of the condenser

Cross-section, Duriron Mixing Nozzle installed in pipe line

Table of Pressure Losses with Duriron Mixing Nozzles

Size Nozzle	Barrels per Hour	Pressure Drop per Nozzle, Lbs. per Sq. In.
3″	40	6
4″	75	6½
6″	200	6
8″	375	8
10″	500	8
12″	1000	10

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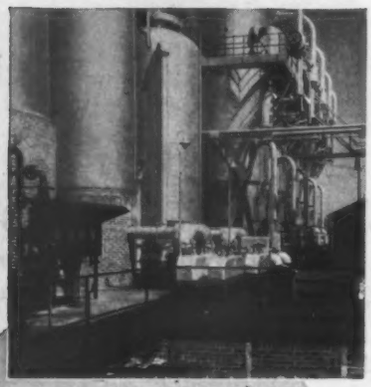

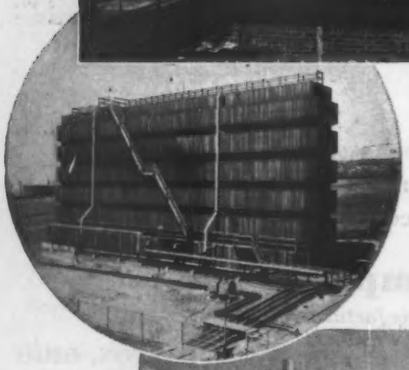

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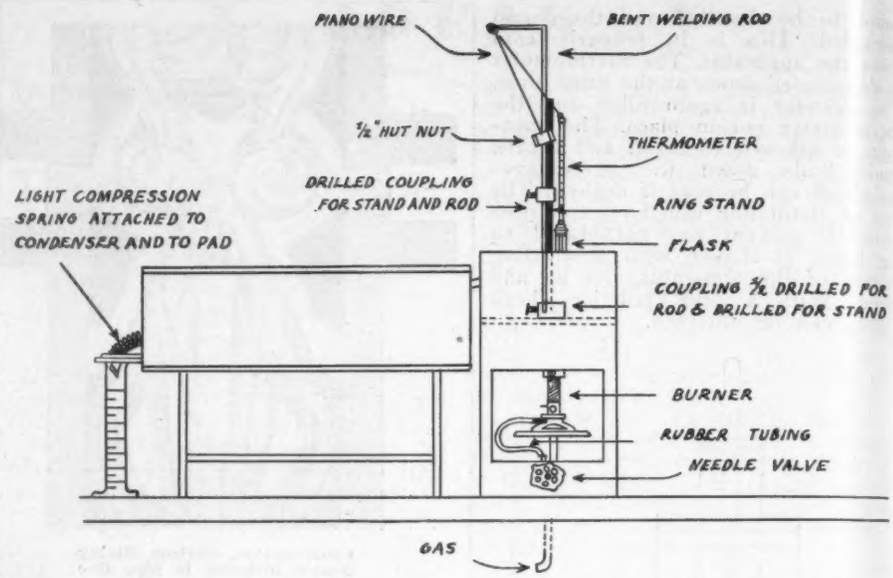


tube is equipped with a light compression spring attached to the condenser box and fitted with a felt-covered composition pad which presses down against the top of the receiving graduate, and this aids in reducing gas losses. The receiver may be slipped out from under the pad easily and without touching the pad. Units such as this when set up in pairs or groups of four make quick work of routine distillation testing.

C. W. BERGER,
McPherson, Kansas.

Novel Vapor Header Design

WHEN Roosevelt Oil Company, Mt. Pleasant, Michigan, built its vapor recovery plant, the piping was arranged so it would come in overhead from the various tanks to a scrubber header and condensate accumulator at the unit. Each tank is equipped with its individual vapor line, which is not connected with other lines until it is flanged to the scrubber header.

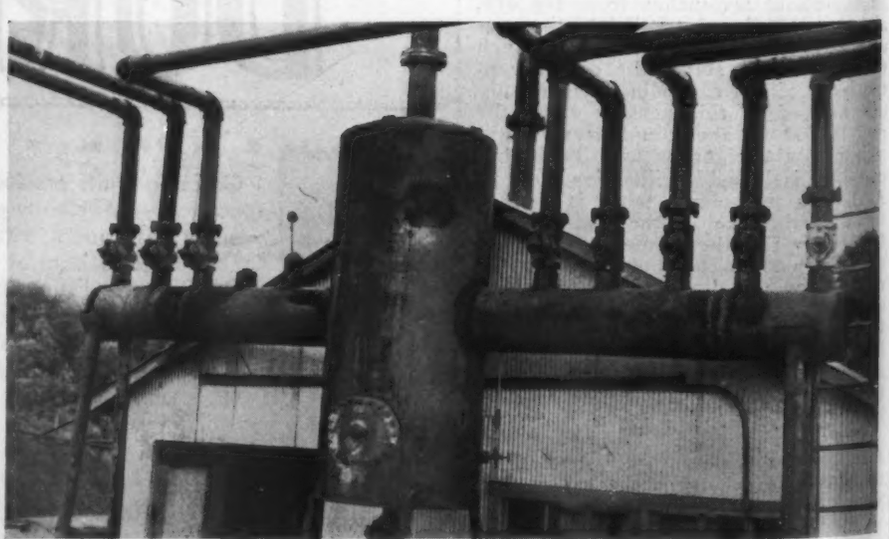
By using the arrangement shown in the photograph, it is possible for the operator to cut out any tank by operating a lubricated plug valve in the compressor room. Also, additional connections were provided so that other tanks may be connected to the header.

The idea back of this design was to provide ease of control of the vapors coming from the run-down and storage tanks, without the necessity of the operator walking through the tank farm. By having individual lines, no mistake can be made as to what line is to be shut off or opened.

Heat Shields Aid Operation

IRREGULAR operation of certain gas engine units furnished a puzzle that stumped the entire operating personnel. An engine would run regularly for some time, then suddenly begin firing erratically, loping or even backfiring for a few minutes, then settling down again for steady running.

Everything was checked and cross-checked, and cylinders 3 and 4 finally brought under suspicion. This held good for all the engines which had been giving trouble, but this fact only



Vapor header used to connect lines which come from all directions to vapor recovery plant.

increased the puzzling feature, as no reason could be assigned which would affect only those cylinders of all engines of a battery.

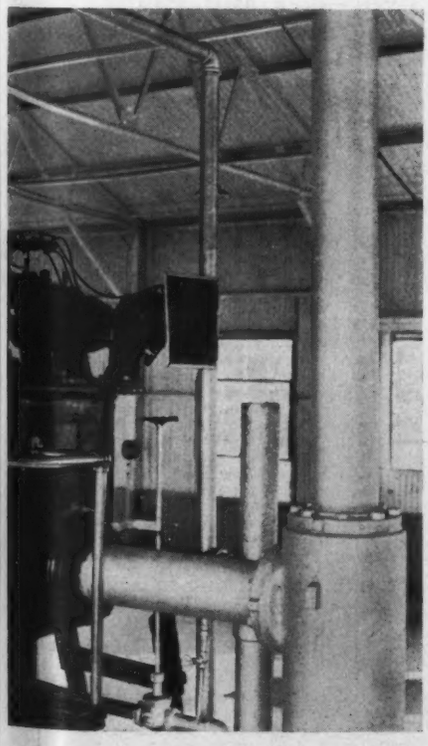
When turned over slowly, or even rotated with starting air, the spark seemed identical for all cylinders, but by cutting out the right hand magneto of each unit while running, it was found that the irregularity could be controlled. Examination of these magnetoes, all serviced within three to six months, showed that in each instance the outer bearing — though carrying a lighter load than the pinion end—had broken down, although these had been packed with grease supposed to stand up for a year.

Due to the wear of these bearings, the distributor end would be forced off center, giving an early spark to two cylinders and a delayed or suppressed break for the other two.

Not until the engineer happened to put a hand on the magneto of one of these units, equipped with a new bearing and functioning perfectly, was a reason for the universal failure of right hand magnetoes discovered. Heat from the nearby mufflers and exhaust pipes raised the temperature of that end of the magneto to the melting point of the grease, it threw out, left balls and races dry.

A shield was formed, from sheet metal, with clamps to fasten on a convenient pipe, and the metal edges turned over to form a recess into which were crimped the margins of a sheet of asbestos packing. This heat shield, standing four inches from the magneto, does not interfere with servicing or adjusting that unit, but so effectively cuts off the radiated heat that the outer end of the magneto shaft now runs appreciably cooler than the one farther from the muffler.

ELTON STERRETT,
Longview, Texas.

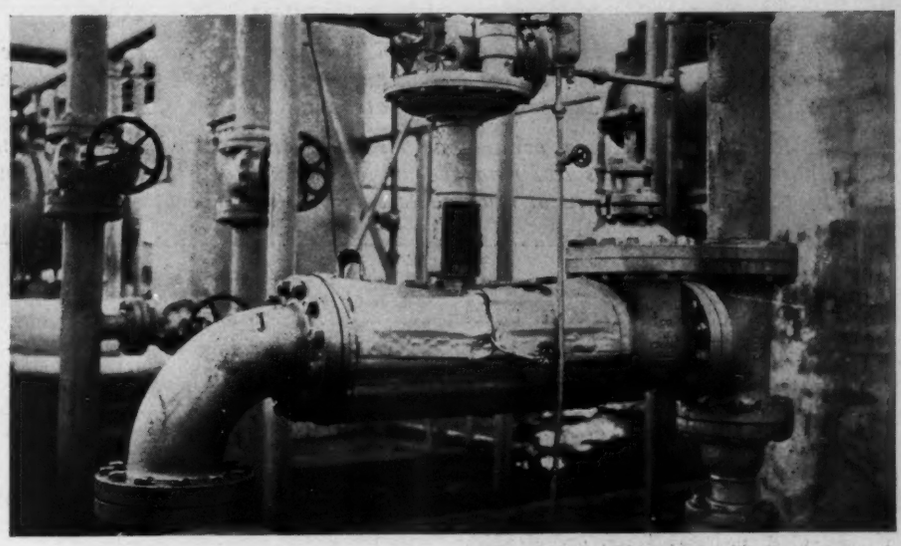


Asbestos-faced shield protects magneto bearing from direct radiation from muffler and exhaust pipe.

Protect Valves From Freezing

WHEN expansion occurs in valves using propane and butane, freezing is prevented at Skelly Oil Company's new gasoline plant at Fairfax, Oklahoma, by wrapping the body of the valve with copper tubing through which live steam flows. This method of preventing frosting has been used for a long time by this company and others manufacturing natural gasoline, but Skelly Oil Company has gone one step further by covering the pipe with insulating material, then housing the entire installation in with sheet metal. After the plastic insulation was applied, the entire valve body was wrapped with galvanized iron which not only prevents disintegration of the insulation, but protects it from becoming water soaked when rain or snow falls.

The unit was fitted with this protective covering and the valves placed in the steam line so that when it is in service no attention is necessary.



Method of expansion valve protection used by Skelly Oil Company, at its Fairfax, Oklahoma gasoline plant.

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by

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under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by tile, by abstract, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Chemical Composition and Reaction:

Formation of Alicyclic Hydrocarbons from Free Radicals. F. O. RICE AND O. L. POLLY. *Ind. Eng. Chem.* **27** (1935) pp. 915-6.

The cracking of straight-chain hydrocarbons of high molecular weight is accompanied in some degree by the formation of naphthenic hydrocarbons. There are several mechanisms through which this may occur, one of which is dealt with in the paper, namely, the rupture of the original hydrocarbon of high molecular weight to form two free radicals which then decompose successively into cycloparaffins and smaller free radicals. Examples of such decompositions are given. Diheptyl mercury was decomposed at about 350° C. and the products obtained fractionated; cyclohexane and other unidentified cyclic compounds were found in the products. Since the diheptyl mercury was diluted to a large extent with an inert gas, carbon dioxide, it appears probable that the cyclohexane was produced by direct decomposition of the heptyl radical rather than by some polymerization of ethylene.

The Catalytic Isomerization of n-Heptane, n-Octane, and a-Hexane Under Pressure. PETROV, MESHCHERYAKOV, AND ANDREEV. *Ber.* **68** (1935) pp. 1-5.

Studies of the isomeric changes of acyclic hydrocarbons under normal and high pressures show the increase of isomerization with rising temperature and the use of halide catalysts. Normal hexane and normal heptane are stable. Olefin hydrocarbons tend to move the double bond from the α-to the β-position, which appears to be necessary to the formation of dimers with iso-structure. The authors studied the question as to whether isomerization of low-molecular weight paraffins and olefins is possible without polymerizing and cracking. For the olefin hydrocarbons the temperature of isomerization, polymerization and cracking proved to lie close together. Normal octane is isomerized at 410° C. in the presence of molybdenum sulphide, and at 440° C. marked rearrangement occurs with considerable cracking. Molybdenum sulphide has more isomerizing effect than zinc chloride but less than aluminum chloride. The authors conclude that destructive hydrogenation and catalytic hydrogenation under pressure offer important advantages over reforming-cracking. To reduce losses it appears desirable to conduct reforming-cracking of gasoline by direct distillation in the presence of active isomerizing catalysts and at lower temperatures. The experimental work is described in some detail.

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Thermal Reactions of Gaseous Hydrocarbons. G. EGLOFF AND E. WILSON. *Ind. Eng. Chem.* **27** (1935) pp. 917-33.

In cracking of pure hydrocarbons the reaction products vary both in kind and amount, depending upon temperature, contact time, initial concentration, and pressure. The production of one product at the expense of other products depends on an understanding of the primary and secondary reactions. The primary reactions of some hydrocarbons have been carefully studied, but for any one hydrocarbon the mechanism of the decomposition has not been definitely traced and proved. Many discrepancies exists in the numerous data available. An attempt has been made to obtain a more complete picture of the thermal reactions of the gaseous hydrocarbons including methane, ethane, propane, the butanes, ethylene, propene, the butenes, diolefins, acetylene, methyl- and ethylacetylene, cyclopropane, and cyclobutane. Mechanism of the thermal reactions of these hydrocarbons is considered in detail on the basis of the activation energies for the primary and secondary reactions. These lead to an explanation of the decomposition products over the whole temperature range. The thermal reactions of ethylene are taken as the key to the reactions of all other gaseous hydrocarbons since above a certain temperature the reaction products of any hydrocarbon are essentially those of ethylene at that temperature. The complete story of the thermal reactions for these hydrocarbons is obtained by consideration of the reactions occurring below 750° C. These are characterized by differences due to the nature and stability of the particular molecule.

Pyrolysis of Propane in Presence of Water Vapor. J. W. LANG AND J. J. MORGAN. *Ind. Eng. Chem.* **27** (1935) pp. 937-41.

A study was made of the thermal reactions of propane at low partial pressures in the presence of steam. The products were analyzed by fractional distillation and subsequent analysis of the fractions so obtained. Up to 700° C., and at the time of contact used, steam was found to behave substantially as an inert gas, and was therefore utilized to study primary decomposition at partial pressures below atmospheric pressure. The results show that a bimolecular primary decomposition occurs to an extent that cannot be neglected in the calculation of rate constants, and that over the range of temperatures commonly used in the study of primary thermal decompositions, temperature has no effect on the proportions of primary products obtained from propane; the proportion of propylene to ethylene in the unsaturated hydrocarbons obtained in the commercial cracking of propanes may be increased at higher pressures. A critical study was made of the proposed mechanisms of hydrocarbon reactions, and it is shown that none of the hypotheses currently advanced explains adequately the primary thermal decomposition of propane but that the mechanism may be explained by Nef's dissociation hypothesis.

Critical Phenomena in the Oxidation and Self-Inflammation of Hydrocarbons. A. EGERTON AND A. R. UBBELOHDE. *Nature,* **135** (1935) pp. 997-998.

Naumann and Aivazov's phenomenon of a negative temperature coefficient for the combustion of hydrocarbon mixtures under certain conditions seems well established. The peroxide theory postulates that the oxidation of the hydrocarbon to an aldehyde takes place through an intermediate peroxide. However, under favorable circumstances this intermediate stage can result in chain branching and hence eventually in ignition at a lower temperature. The conditions favoring chain branching are important in connection with knocking. Anti-knocks lower the effective concentration of the intermediate peroxide, while the effective pro-knocks all disrupt in such a manner as to lead to a similar type of branching, that in turn leads to reformation of the peroxide.

Manufacture: Processes and Plant

Rate of Heat Transfer Between Condensing Organic Vapors and a Metal Tube. F. H. RHODES AND K. R. YOUNGER. *Ind. Eng. Chem.* **27** (1935) pp. 957-61.

The rate of transfer of heat from a vapor condensing on the outer surface of a tube is usually computed by means of the Nusselt equation. On account of the fact that this equation has not been adequately tested by experiment, and because most of the work done has been done with steam, which often, if not usually, condenses in separate drops and not in a continuous film, as assumed by Nusselt in deriving his equation, the authors engaged in an experimental study of condensing coefficients for organic vapors. The procedure used is described. Benzene, toluene, pentane, hexane, octane, acetone, ether, ethyl alcohol and butyl alcohol were studied. It was found that within each homologous series of compounds the thermal conduction decreases by an almost constant amount from one member of the series to the next. In every instance the calculated value of the coefficient was lower than the observed, or actual value, although the difference was usually less than 10 percent. A few experiments were made on the effect of fouling, which was limited to slight fouling, and it was concluded that a decrease of 10 to 20 percent in heat transmission could be caused by limited fouling.

Continuous Coking in a Dubbs Unit of Astra Romana at Ploesti, Roumania. L. F. K. VAN DONGEN AND W. A. KEIGHTLEY. *La Revue Petrolifere,* **641** (1935) p. 957.

In order to make coking continuous two reaction chambers are used in parallel in some instances. In another procedure for continuous coking used with success in recent units, the residuum is coked in alternate chambers under low pressure. The necessary control of heat is accomplished by injecting hot oil into the chambers receiving the residuum to be

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treated. Astra Romana has adopted a procedure that includes direct heating of the residuum before its passage into the coking chambers. Waste heat is used for this purpose. The residuum passes from the reaction chamber of the Dubbs unit into the coking chamber through the superheater. The vapors resulting from coking are mixed directly with the crude oil and used as charging stock to the unit. The quality of the distillate and the resulting gasoline differs little from that obtained in coking under pressure. The coke can be controlled within wide limits of hardness and volatility. Continuous coking gives greater capacity because of the infrequent interruption of operation; also because the reaction chamber of the cracking plant is not fouled by the accumulation of coke. Costs of plant operation have been materially reduced.

Production of Gasoline by Polymerization of Olefins. C. R. WAGNER. *Ind. Eng. Chem.* **27** (1935) pp. 933-6.

In the operation of low-pressure, vapor-phase cracking processes 20 to 30 percent of the gas oil content of the charging stock appears as fixed gas, depending upon the temperature of cracking and the character of the fuel oil or residue produced. Gases containing 20 to 24 percent of ethylene, 13 to 18 percent of propylene, and six to 10 percent of unsaturates in the four-carbon group were polymerized by the action of heat and pressure in the absence of catalysts. On a once-through basis 1.7 gallons of gasoline per thousand cubic feet were obtained when operating at 950° F. and 800 pounds pressure; by recirculating the gas derived from the stabilization of the cracking plant gasoline the yield from the polymer plant was increased to 3.0 gallons per thousand cubic feet. In a commercial unit the yield was improved to 3.25 gallons. By processing gas derived only from the stabilization of vapor-phase cracked distillates 9.0 gallons were obtained. By operating at low pressure, but at 1200° to 1300° F., the liquid products were largely aromatic. The flow sheet of a typical plant is given, as well as tabular data covering typical gases and results of test runs under various conditions.

Removal of Mercaptans from Naphtha by Caustic. J. HAPPEL AND D. W. ROBERTSON. *Ind. Eng. Chem.* **27** (1935) pp. 941-3.

In order to produce gasoline, naphtha or kerosene that is doctor sweet the mercaptan sulphur content of a distillate must not exceed about 0.001 weight percent of mercaptan sulphur. Caustic soda is an effective reagent for use in reducing the mercaptan content of naphthas. However, because of the weakly acidic nature of these substances, they can be only partially removed by direct caustic washing, and such washing must be followed by a sweetening process to remove the final traces. The two-phase system of naphtha and aqueous caustic solution will contain mercaptan in three forms; free (HSR) dissolved in the oil and in the caustic layer (NaSR), and (SR-) ions. The ratio of ion concentration of mercaptan in the aqueous and oil layers, that is the distribution coefficient, should be a constant. Composition of the light cuts from Luling crude, in terms of mercaptans before and after caustic washing, is given. A method of calculation for calculation of number of contacting stages for a given ratio by volume of caustic and naphtha is given. This procedure is applied to a specific case.

The Refining of a Cracked Motor Spirit. D. G. JONES. *Jour. Inst. Pet. Tech.* **21** (1935) pp. 709-24.

The vapor phase refining of a cracked motor spirit produced in the Argentine is described. The cracking plant comprises two 1000-barrel hot-oil Cross units. The present stock is a gas oil of 0.890 specific gravity. Gasoline vapors and gas pass overhead to the Gray tower system. Gasoline produced by the cracking plant is corrosive, has a bad color, a high gum content, and disagreeable odor, associated with hydrogen sulphide, mercaptans, and other sulphur compounds. The contacting towers are five single shell 11-foot diameter towers having a nominal clay capacity of 16 tons. Clay is supported on a perforated plate covered with a 40-mesh monel-metal screen. By changing the vapor inlet from the shoulder of the towers to the charging manhole at the top, the capacity of the towers was increased to 28 tons of clay. A local clay is used rather than Fullers earth. Upon leaving the clay treating and rectifying plant the cracked gasoline has a +30 Saybolt color and less than five mgms. of gum, but is unstable and contains free hydrogen sulphide and mercaptans. It is stabilized and treated with a lime wash. Details of the various procedures are given.

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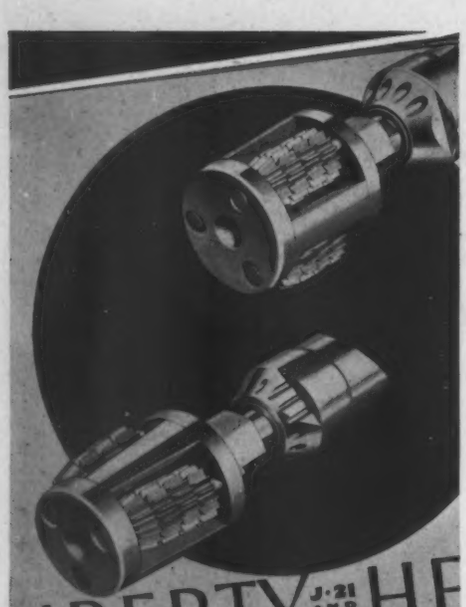

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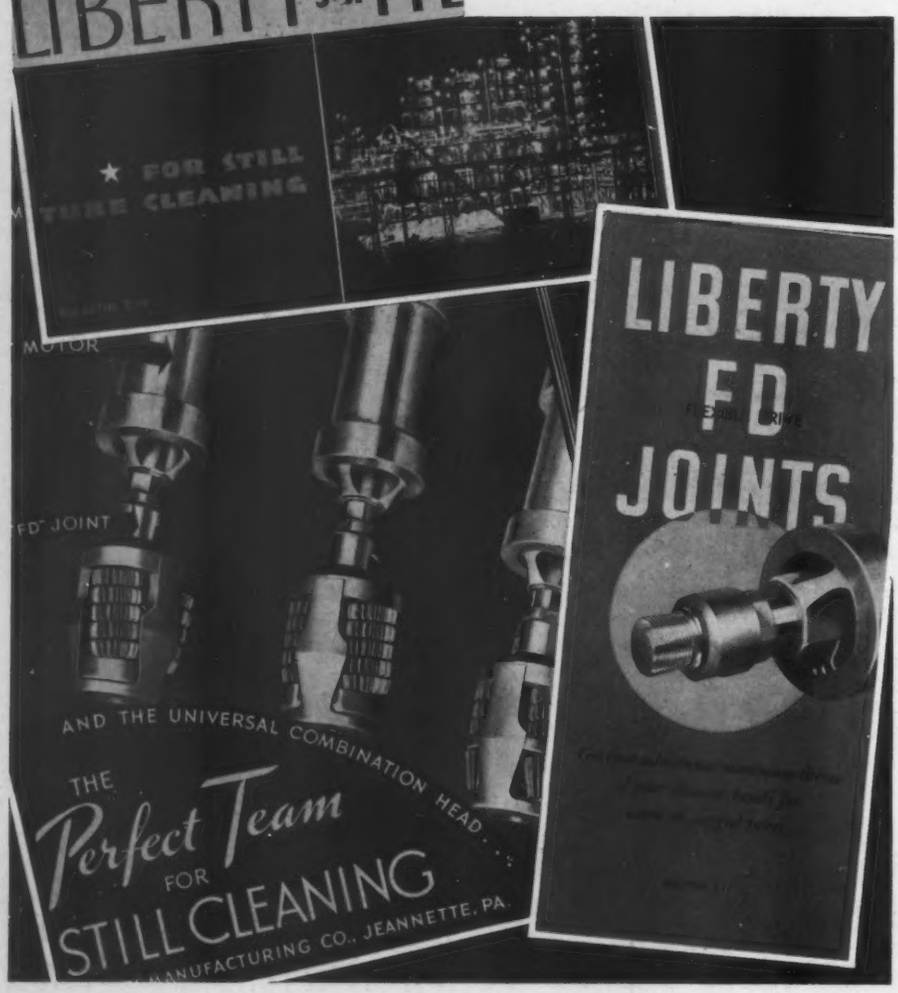

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bons by Condensation Processes. HORST BRUCKNER AND ALBERT LANG. *Brennstoff-Chem.* **16** (1935) pp. 126-8.

Treatment of so-called "prebenzine", from the activated carbon absorption process, with anhyd. zinc chloride, zinc chloride and infusorial earth, anhyd. aluminum chloride, and anhyd. ferric chloride, is discussed. For equivalent degrees of refining a loss of five percent was had with 0.33 percent $FeCl_3$ is compared to 8.5 percent loss using 90 percent sulphuric acid and alkali washing. Prebenzine recovered by wash-oil scrubbing of gas required five percent ferric chloride and gave higher losses. The procedure can be simplified by using ferric chloride in methyl alcohol solution.

The Regeneration of Lubricating Oils. ERICH BOSSING. *Chemiker-Zeitung*, **59** (1935) p. 557.

Before treating a used lubricating oil with sulphuric acid the water must be separated by standing for some time at 50° C. Two percent of sulphuric acid is mixed with the oil, the sludge separated, and the oil is then distilled under vacuum and filtered through Fullers earth. In another method the oil is fully heated for several hours to 60° C. using six percent of sulphuric acid. Slow heating prevents new polymers from forming. Such polymers, if formed, later catalyze oxidizing reactions with the oxygen of the air. Used oil can be clarified by a polymerizing treatment using aluminum chloride, stannic chloride or phosphoric acid. From two to five percent of the polymerizing agent is sufficient. An excellent oil is made by centrifuging to remove water and solids and then mixing the oil with sodium phosphate, heating and centrifuging again. Oil can be clarified by treatment either with a solution of soda or one to three percent of solid caustic. After thorough mixing by means of air, warming to 100° separation of coarse impurities the oil can be finished by centrifuging to remove fine impurities. Coagulents such as sodium phosphate, sodium carbonate and sodium silicate are useful for purifying used oils. Various patented processes are reviewed.

New Protective Coatings for the Protection of Structural Steel. B. SCHEIFELE. *Paint Varnish Production Mgr.* **12** (1935) pp. 14-15, 16-17.

The oil-modified Glyptal resins, both alone or in combination with nitro-cellulose, offer new possibilities as under and top coats for structural steel. Red lead retains its rustproofing power in synthetic resin vehicles and also in chlorinated rubber, as well as in linseed oil protective coatings.

Fundamental Physical Data

Determination of Vapour Pressure of Hydrocarbons. SCHMITT. *Ann. des Comb. Liq.*, **10** (1935) pp. 268-270.

In determining the vapor pressure of hydrocarbons the liquid is freed from dissolved gas by repeatedly solidifying in liquid air and subjecting to a high vacuum. The relationship between pressure and temperature is given by Antoine's formula $\log p = A + \frac{B}{C+t}$ and the heat of vaporization by the Clapeyron formula $L = 4.57B.\frac{T^2}{(C+t)^2}$. The values of the quantities in these equations are given for n-hexane, methylcyclopentane, benzene and toluene.

Viscosity of Hydrocarbon Solutions. B. H. SAGE, J. E. SHERBORNE AND W. N. LACEY. *Ind. Eng. Chem.* **27** (1935) pp. 954-6.

When hydrocarbon gases are dissolved in liquid hydrocarbons, marked decreases in density, surface tension, and viscosity, result. These changes have an important bearing upon the processes involved in the production of crude petroleum. The present paper deals with the results of a study of viscosity changes resulting from solution of methane and of propane in an oil known as crystal oil, under conditions of equilibrium temperature and pressure commonly met in petroleum production practice. Data are presented in tabular and graphical forms, and show the effect of concentration on viscosity, temperature at different pressures on viscosity, and viscosity at constant composition but at different tempera-

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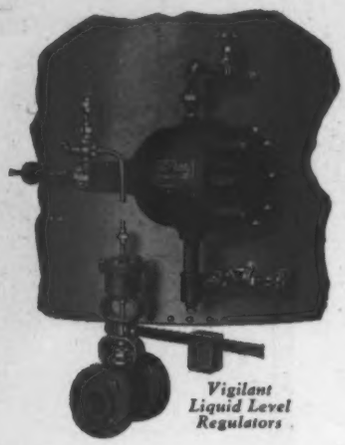

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tures. These data are given both for methane and propane.

Conductivity of Oils and Waxes. A. GEMANT. *Nature* **135** (1935) p. 912.

Some years ago the author detected a region of negative temperature co-efficient of conductivity of heavy oils; that is, a rising conductivity with decreasing temperature occurring in the neighborhood of the solidifying point. Paraffin wax has been observed to behave similarly by W. Jackson, and the effect is probably a characteristic of hydrocarbon oils and waxes. The transition between the glassy and crystalline phase in an oil must extend over a range of temperature, and the conductivity in this range is therefore that of a two-phase system.

Products: Properties and Utilization

Effect of Tetraethyllead on Preflame Reactions in an Engine. L. WITHROW AND G. M. RASSWEILER. *Ind. Eng. Chem.* **27** (1935) pp. 872-9.

The suppression of knock by tetraethyllead was studied. Strong evidence exists for the conclusion that lead in some way inhibits preflame reactions. The use of absorption spectra to study engine combustion is most satisfactory because it does not disturb the environment in which the combustion reactions occur. Work done on absorption spectra of the gaseous charge of the engine indicates that when tetraethyllead is added to the fuel to prevent knocks there is an effect on the preflame reactions in that portion of the charge which, in the absence of tetraethyllead, suddenly inflames at the time of knock. Atomic lead has been identified in the non-inflamed charge in the knocking zone at the moment that anti-knock action is being effected, but no accompanying absorption by lead monoxide has been observed. When lead is vaporized in a hot nichrome tube the absorption spectra exhibit lead monoxide bands at lower temperatures than atomic lead lines. Comparison of experiments in and out of the engine indicate that lead monoxide is being reduced in the non-inflamed charge.

Connection Between the Physical Properties and Chemical Constants of Lubricating Oils. M. FREUND. *Petr. Zeit., Motorenbetrieb und Maschinenschmierung* **8** (1935) pp. 1-6.

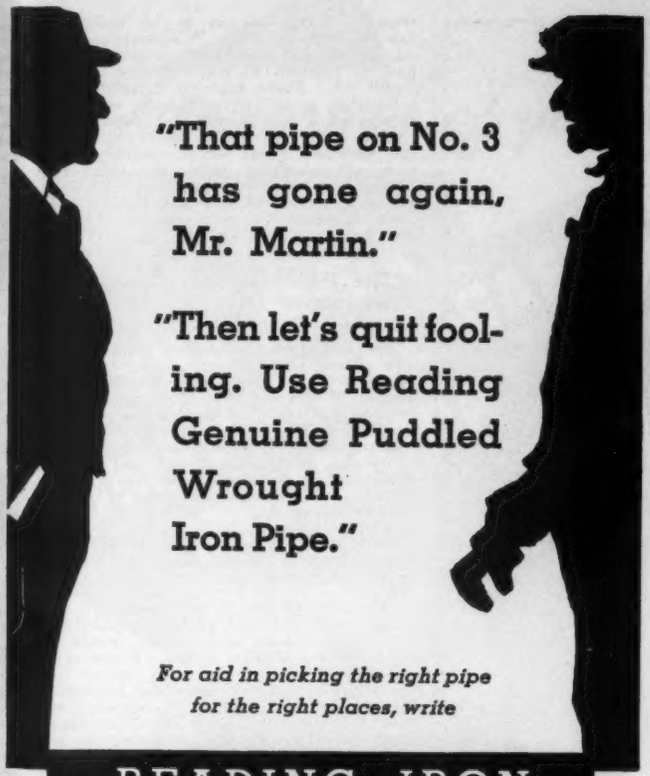
The properties of refined natural mineral lubricating oils of the same viscosity at 50° C. were compared. As specific gravity increases the mean boiling point, analine point, apparent molecular weight, and the hydrogen content of the oils decrease regularly. The viscosity/temperature curve becomes steeper, the value for Conradson carbon generally decreases and the content of aromatic or reactive hydrocarbons as well as the ease of oxidation increase. The method of refining influences the relation of the properties of the oils. Tables of analytical data are given.

Oxidation of Mineral Oils by Gaseous Oxygen at Moderate Temperatures. G. MULLER. *Compt, rend.* **200** (1935) pp. 1769-72.

The absorption of oxygen by various transformer oils at a temperature of 110° C. was studied for periods up to five hundred hours. Absorption figures are expressed for a time of four hundred hours. Most highly refined white oils absorb most, 4-10 l./100 cc. Partially refined oils usually absorb the least, and slightly refined oils an intermediate amount. Addition of copper stearate as a catalyst has little effect on the white oil, but increases the absorption from the other oils. Although peroxide appeared to be formed at first, none was found in the cooled final oil. The products formed in the order of increasing amount were volatile acids, alcohols, fixed acids, ketones, non-volatile sapond. matter, and water. Three to 10 percent of the absorbed oxygen formed compound was deposited.

The Behavior of Motor Oils in the Cold. A. BAADER. *Erdol u. Teer* **11**, (1935) p. 471.

The temperature at which an automobile oil pours is not as important as the temperature at which it becomes so viscous that it can no longer function to fulfill its purpose. An oil may become useless through increased viscosity at a point much higher than its solidifying point. Five commercial brands of motor oil were tested as to their behavior in the cold. The oils were placed in a tube and the temperature reduced to —35° C. and held at that temperature for thirty minutes. The time



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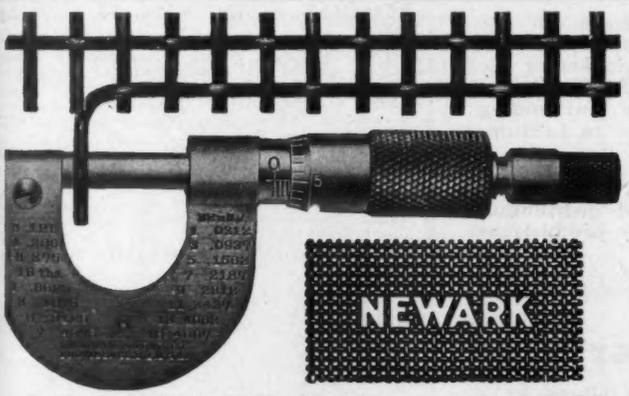

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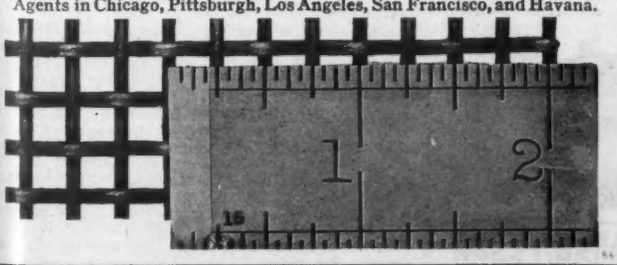

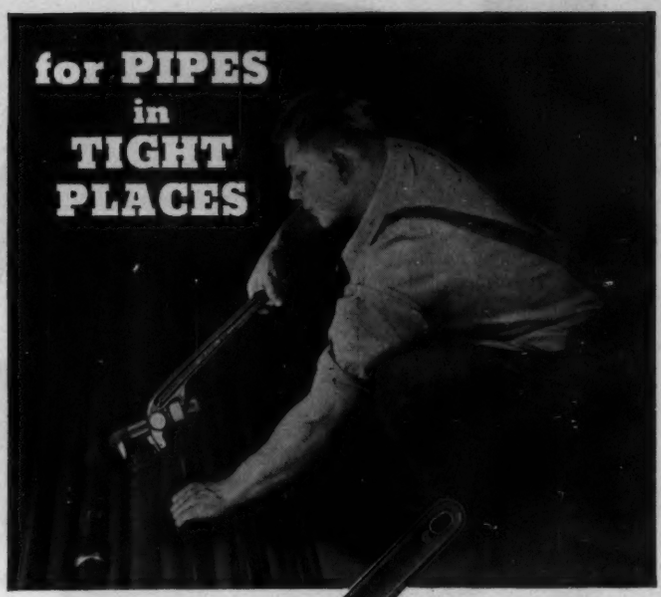

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required for a weight to be pulled through the oil was measured. Viscosity of the cooled oil, called the solidifying viscosity, apparently had no relation to the viscosity curve of the liquid oil. There was no correlation between solidifying point and solidifying viscosity. The setting of a specification for maximum viscosity at —20° C. would involve the fixing of the turbidity point since viscosity determinations are unreliable below the turbidity point. Vapor loss from any oil should be limited to seven percent. This would prevent the practice of diluting with light oils to obtain a low pour point or low viscosity. There is no parallelism between flash point and vapor loss.

The Possibility of Mixing Different Transformer Oils. R. H. GOLDE. *De Ingenieur* **49** (1934) p. 173.

The author reviews recent work on this subject. Destructive effects such as accelerated aging were not observed when Russian transformer oil was added to oils from Pennsylvania or Texas. German regulations recently promulgated allow the mixing of oil if the difference of density is less than 0.05, in viscosity 1° Engler, and in the H_2SO_4 test two percent. If the oil in the transformer has aged too extensively, added new oil may at times show accelerated aging.

Lubricating Oils and Greases. F. J. MATTHEWS. *Colliery Eng.* **12** (1935) pp. 86-8.

The substitution of cottonseed or rosin oil in the lubrication of high-grade machinery must be avoided. Lard and tallow attack copper, and tallow attacks iron. However, small amounts of these oils when added to other mixtures increase the spreading properties. The friction between two solid surfaces depends upon the viscosity of the oil. The higher the speed and the lower the pressure, the less viscous is the oil required. Fatty oils become oxidized and gummy in the presence of air, and in the presence of moisture they decompose to form acids. A comparison is made of the lubricating properties of mineral, vegetable and animal oils. It has been found in the lubrication of steam turbines that oils of paraffin base are less likely to emulsify than those of asphalt base. Lead, aluminum, zinc and magnesium soaps are discussed as lubricants.

Determination of the Acid Value of Motor Spirit. K. R. DIETRICH AND H. GRASSMAN. *Z. Spiritusind,* **58** (1935) p. 188.

Phenolphthalein is not a satisfactory indicator for use in the titration of the acids present in gasoline because of the effect of dissolved carbon dioxide. Me-red can, however, be used in the titration without previous boiling. Titration figures for small amounts of AcOH, $EtCO_2H$, Pr^nCO_2H, and decoic acid, using Me-red for indicators, are less than theoretical, but with more than 2.5 mg. of acid for 100 cc. of gasoline the error is not significant. Account of the greater accuracy made possible by the use of Me-red, it is suggested that the amount of acid allowable in gasoline be reduced.

Improved Method of Examining Mineral Oils, Especially the High-Boiling Components. II. J. C. VLUGTER, H. I. WATERMAN AND H. A. VAN WESTEN. *Jour. Inst. Pet. Tech.* **21** (1935) pp. 701-8.

The authors discuss and illustrate the use and determination of specific dispersion as a means for determining the presence or absence of aromatic rings in oils. The specific dispersion is the difference between two refractive indices, determined at different wavelengths of light, divided by the specific gravity. A table of the specific dispersions of aromatic, naphthenic and paraffinic compounds is given.

Estimation of Color of Mineral Oils by Means of Absorption Measurements. E. LEDERER. *Petr. Zeit.* **31** (1935) No. 21 pp. 1-4.

Absorption measurements were made as far as possible over the whole range of the spectrum, using a Pulfrich Photometer. The author devised a formula for estimating the color of an oil by means of two constants, one for color depth, F_t, the other, color shade, F_s. These values are read from a specific Raster system. Color depth is defined as the log. of the extinction coefficient at the point of maximum intensity in the solar spectrum (530 mu). Color tinge is defined as the tangent of the angle of inclination of any straight line through which the log. of the extinction coefficient is represented in the Raster system. The greater F_s, the greater the red tinge and the less the yellow tinge of the oil. The greater F_t the darker the color.

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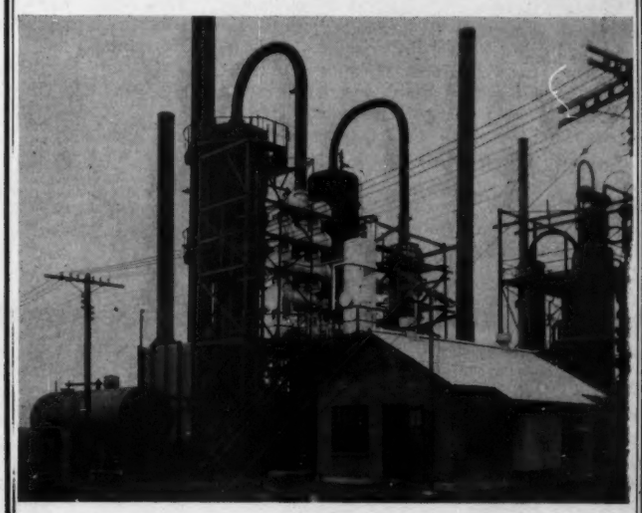

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CHICAGO PNEUMATIC TOOL CO.

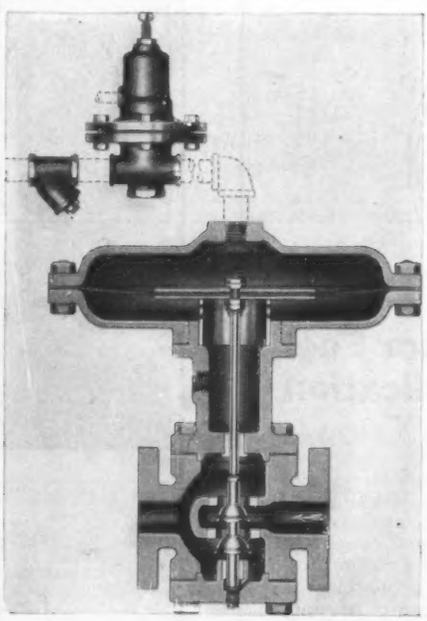
Chicago Pneumatic Tool Company, New York City, has announced a complete new line of air compressors which the manufacturer claims embody many refinements and improvements. The new compressors feature improved intercooling, force feed lubrication, durable valves, simplicity and quiet operation. Low maintenance cost is claimed because of the fewer cylinders to maintain and ease of inspection and adjustment.

The three types of drive include the built-in motor, coupled, and V-belt. The built-in motor type has the motor stator mounted on compressor crankcase and the rotor keyed to compressor crankshaft. A pilot bearing in the outer motor bracket insures alignment. The unit may be bolted directly to the floor. It is available only with the 50- or 60-cycle squirrel cage motors. With the coupled motor drive the motor is connected through flexible coupling to compressor and the entire unit mounted on structural steel sub-base. This type is for use with all types of motors. The V-belt drive type is available with or without sub-base, and for use with any kind of prime mover.

Regulator

THE McALEAR MANUFACTURING CO.

The McAlear Manufacturing Company, 1901 South Western Avenue, Chicago, Ill., announces a new gas pressure regulating valve for control of furnace temperatures.



McAlear Regulator

The valve is fundamentally a pressure balanced unit, i. e., its operation depends entirely on equalized pressures in the upper and lower diaphragm chambers of the main valve. Either air or clean, dry gas may be used as the operating medium. This medium is piped through the pilot valve to the top of the main valve diaphragm and is maintained by the setting of the pilot at a pressure slightly lower than that which is to be controlled by the main valve. The pressure to be controlled is piped from the downstream side of the valve to the lower diaphragm chamber. Thus, the slightest increase in the downstream pressure exerts its force on the under side of the diaphragm and tends to close the valve. Conversely, a drop in pressure causes the operating medium above the diaphragm to throttle or open the valve.

The valve is said to be suitable for inlet pressures up to 100 pounds and is easily adjusted to maintain combustion pressures at any point from four ounces to 35 pounds. Two types of pilot valves are offered: one with screw adjustment for direct mounting on the regulator, or one with an adapter and composition hand wheel for mounting on a panel board to permit control of gas pressures to burners from a centralized control room or some other remote point. The valves are made in sizes one half-inch to six inches, inclusive.

Total Time Meter

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY

Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., announced a new total time meter for totalizing running or idle time on electrically operated machinery including machine tools, welders, or any individual a-c powered unit. The meter registers hours and it is suitable for any application where it is desired to know the total number of hours during which a circuit is energized or apparatus is in operation. The registering mechanism has four dials and will register 9,999 hours before repeating, approximately 400 days. If desired, the meter can be mounted in the superintendent's or foreman's office connecting it to the machine by a single pair of wires.

The total time meter including the self-starting, 120-volt, a-c, 60-cycle, synchronous motor is contained in a two-piece Moldarta case having a flange diameter of 3½ inches and overall length of about 3¼ inches. The motor is of the slow-speed, sub-synchronous type, with jeweled bearings. All parts, such as the register, motor, etc., are readily removable for inspection, repairs or replacement.

The 11-volt and 120-volt styles require approximately 1.5 watts for operation. The 240-volt style requires approximately three watts. The synchronous motor will stay in step with voltages 12 percent above or below normal values.

The total time meter can also be furnished with a special register providing one revolution per hour of the sweep hand. The sweep hand dial is then marked in 10 main divisions each of which represents one tenth of an hour. This register reads up to 9999.9 hours before repeating. The above register is particularly useful for production checks where it is desirable to obtain data in fractions of an hour.

Welding Rod

THE LINDE AIR PRODUCTS CO.

The Linde Air Products Company, New York City, has announced a new stainless steel welding rod for welding chrome-nickel steels of the 18-8 type. Known as Oxweld No. 28 Columbium-Treated 18-8 Welding Rod (patent applied for), this is an important addition to the Oxweld line of welding rods. It simplifies the fabrication of products from 18-8 stainless steel and greatly improves the corrosion-resistance of the fabricated joint areas, the manufacturer claims.

The outstanding and unique feature of the new rod is the inclusion of a definite quantity of the element columbium. Because of this feature, products fabricated from "treated" or "stabilized" 18-8 steel by welding with Oxweld No. 28 rod have full corrosion resistance and heat resistance in the as-welded condition. No heat-treatment after welding is necessary.

Water Treatment

D. W. HAERING & COMPANY

D. W. Haering & Company, 3408 Monroe Street, Chicago, announces development of sodium chrom glucosate, an alkaline organic chromate for the control of corrosion in brine systems, condenser systems, and other aqueous systems where water is not used for human consumption.

This new chromate chemical provides efficient corrosion control in brine systems between a pH of 6 and 12, offering a wider range of protection than is possible with the inorganic chromates.

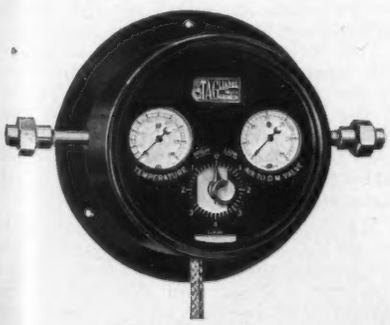
The material may be used in quantities of 50 pounds per 1000 cubic feet of calcium brine and 100 pounds per 1000 cubic feet of salt brine. Approximately one pound per 20,000 gallons is required to treat the average condenser water for chromate protection.

This alkaline chromate requires no adjustment before introduction and may be used safely in open systems without the development of chrom itch.

Controller

C. J. TAGLIABUE MFG. COMPANY

C. J. Tagliabue Manufacturing Company, Park and Nostrand Avenues, Brooklyn, N. Y., has placed on the market a new instrument to be known as Tag Number 40 Controller, which is said to be suited to the majority of automatic control applications.



Tag Controller

The principle of control is basically the TAG movement, which has been redesigned for compactness in such a fashion that the few simple parts are accessible with exceptional ease. Tube systems can be interchanged with surprising facility.

A novel spring lever designed to eliminate all lost motion multiplies the movement of the powerful capsular spring for sensitive yet positive control. The smallest change in temperature is transmitted positively and with great precision to the TAG ball air valve which in turn resets the rate-of-flow through the diaphragm actuated control valve. In the TAG Number 40 Controller the sensitiveness is high and the accuracy is permanent.

Indicating and non-indicating types in nine convenient temperature ranges and three pressure ranges are available in this new controller.

Meter

NATIONAL METER COMPANY

National Meter Company of Brooklyn, New York, manufacturers of Empire positive displacement gasoline and oil meters, has perfected a new automatic register which it is marketing under the name of the "Measurmatic" register.

This new register is adaptable to all meter sizes. It has a convenient and plainly graduated vertical dial and a large indicating hand. As small a quantity as one tenth of a gallon can be easily read.

The "Measurmatic" register can be pre-set by a single knurled knob to any desired quantity from one to 1000 gal-

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VAPOR RECOVERY SYSTEM

SURE is a money maker!

"It's been in operation just a little over a year and already has amortized its cost through saving the gases that we used to pass to the atmosphere. The figures substantiate my recommendations for S. & J. gas tight tank fittings and vapor recovery."

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S. & J. offers a complete line of gas tight petroleum tank fittings for the automatic conservation of gases. Individual units and complete system assemblies are illustrated and described in our new catalog No. 52-B. Write for a copy today. It will point the way to increased earnings.

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Gasoline lines that were running at 115° to 120°F, dropped to 90° to 95°F, demonstrating the efficiency of Oakite cleaning.

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PRESSURE AND FLOW CONTROL APPARATUS

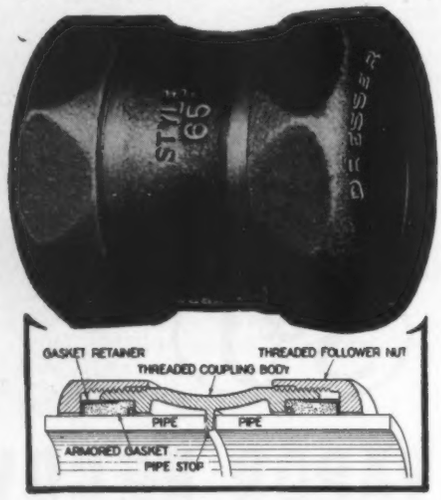
lons. The valve control lever can be manually operated at any time during the run, without in any way affecting the pre-set quantity or the accuracy. The control valve is equipped with a shock absorbing cushion, eliminating the danger of damage to hose or pipe line connections due to sudden valve shut-off shock.

With the "Measurmatic" meter, deliveries can be made single-handed to remotely located tanks with no danger of spills and with absolute safety. It will also enable the loading-rack operator to load multiple compartments simultaneously without danger of overfilling.

Pipe Coupling

S. R. DRESSER MANUFACTURING CO.

S. R. Dresser Manufacturing Company, Bradford, Pa., has introduced a new type pipe coupling for plain end pipe. The new coupling, which is a form of union, is a simple pipe joint that may be connected in a short time with a wrench. It



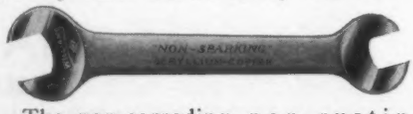
Dresser Coupling

consists of octagonal followers, gasket retainers, armored gaskets and coupling body. Making the joint involves inserting the pipe ends into the coupling (which comes assembled) and then tightening two threaded octagonal nuts with a wrench, the entire operation requiring a very short period.

Safety Wrenches

J. H. WILLIAMS & CO.

J. H. Williams & Co., 75 Spring St., New York, announces a new "Non-Sparking" Safety Wrench for use in industries where fire hazards exist. Drop-forged from Beryllium-Copper and accurately heat-treated they are said to be superior in strength, toughness and hardness to wrenches made of any other known safety material.



The non-corroding, non-rusting wrenches are finished in "Safety-Green" enamel, heads polished bright with opening sizes stamped thereon. They are available in both single and double-head patterns in a wide range of sizes.

Belt Cutter

FLEXIBLE STEEL LACING COMPANY

Flexible Steel Lacing Company, 4607-4631 Lexington street, Chicago, announces an eight-inch flat belt cutting tool said to employ a new principle

in mechanical belt cutting. The cut is made by pushing the knife through the belt from one edge to the other. The knife is mounted on a plunger in a slot and is operated easily by a direct arm push without mechanical leverage. The knife goes "like cutting cheese" through most belting, but it will cut even the thickest and toughest belts up to eight inches in width with surprisingly little effort. The knife, of special alloy steel, will make several thousand cuts and is easily replaceable.

The belt is held immovable by the equalizing clamp or hold down while the cut is being made. The clamp is also a guard for the blade. Clamp and frame are strongly built of aluminum alloy, the weight of the cutter being only four pounds and three ounces.

The cutter is used either on the bench or is up-ended on the floor, if desired.

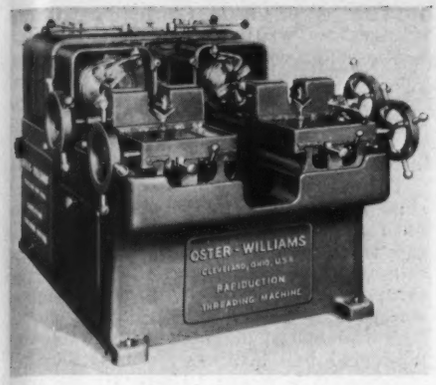
Arc Welder

IDEAL ELECTRIC & MFG. COMPANY

The Ideal Electric & Manufacturing Company, Mansfield, Ohio, has announced the development of a new design of arc welder, featuring unity power factor motor drive, as high as 75 percent over-all efficiency, and an extremely fast arc with almost incredible recovery speed, the manufacturer claims. A unique arrangement of generator windings utilizing a separate auxiliary differential field structure produces an improvement in welding performance. Oscillograph tests show recovery from short circuit to normal welding current in less than .01 of a second. The temperature rise of the machine has no effect on the current and voltage settings in this welder.

The welders provide both 25 and 40 volt operation by a simple adjustment of the controls. This permits the use of the new improved high speed coated rods, as well as standard uncoated rod, and also allows copper arc and carbon electrode work—all on the same machine.

Many other features are claimed for the welder, such as their all-steel welded construction, a dual control system for both voltage and current control, polarity reversing switch and zero center individual current and voltage meters. Another exclusive feature is the automatic brake which holds the welder from rolling when the pulling handle is lifted. These welders are also available for direct current motor drive, and engine drives.



Oster-Williams Bolt Machine

Bolt Machine

OSTER-WILLIAMS

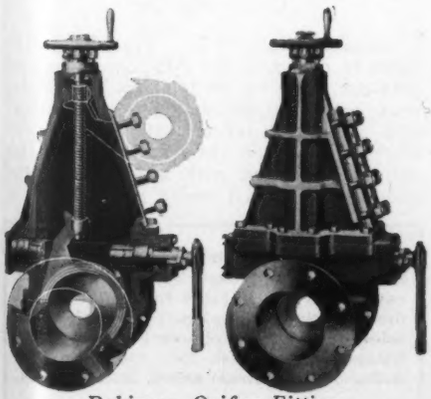
Oster-Williams, Cleveland, Ohio, has announced the new No. 922 bolt machine and will exhibit the model at the forthcoming machine tool show in Cleveland. This new machine which will be furnished in both single and double spindle types is an entirely new design in both appearance and mechanical features, it is claimed. It is built for high production on standard runs in bolt plants and for increased production on an extremely wide variety of special work which goes into a manufacturers product. Its regular bolt range covers all sizes from ½- to 2¼-inch at spindle speeds ranging from 32 to 196 revolutions per minute. A spindle bore of 3¼ inches and a vise adaptable to many different types of work holders, give it wide possibilities for work of special nature.

The double spindle machine is equipped with a mechanical reverse on one spindle so that both right and left hand threads can be cut simultaneously. The design of the No. 922 machine includes the use of Timken bearings throughout and die head of tool steel hardened and ground. All dies are of high speed steel. The spindles are made of high carbon steel forgings, heat-treated and ground.

Orifice Fitting

ROBINSON ORIFICE FITTING CO.

Robinson Orifice Fitting Company, 1453 Santa Fe Avenue, Los Angeles, announces a new orifice fitting for handling gases and liquids. The main operating mechanism, which is entirely enclosed in the upper chamber, consists of a heavy stationary screw and a follower nut, pivoted to the orifice plate carrier. This simple device raises or lowers the orifice plate carrier and forces the carrier into its position in the lower seats. When the plates are to be inspected or changed, the carrier is lifted completely out of the upper chamber and is held in a convenient position for servicing.



Robinson Orifice Fitting

The valve seats are covered in both open and closed positions. A full-floating plug valve is lubricated with an equalized pressure system. It is never necessary to lift the carrier manually because it is supported at all times. The orifice fitting has a quick change cover plate. Positive control of the orifice plate is maintained under all pressures. An indicator definitely shows the operator when the orifice plate is positioned in the pipe line bore. The orifice plate may be locked in place, preventing unauthorized changing of orifice plate setting.

Mason-Neilan Field Demonstration

A NEW field demonstration service believed to be the first of its kind and certain to be of outstanding value to large industries where instrumentation and control are major problems, was recently put into effect by Mason-Neilan Regulator Company of Boston. The new service unit, a specially designed truck, completely equipped with up-to-the-minute reducing valves and control instruments, is making a nation-wide tour, giving demonstrations of modern control in important chemical plants, paper mills, refineries, process and power plants.

This demonstration unit makes it possible for plant executives, process men,

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The processing of low cold test lubricating oils requires refrigeration. Temperatures far below zero are essential in refining this product.

Old Mother Nature has wisely provided us with an insulation material without a peer in the field of refrigeration—CORK. In making *CORINCO CORK PIPE COVERING* for the insulation of cold lines, we merely put CORK in more convenient form. Therefore, by using *CORINCO CORK PIPE COVERING* you are assured of proper refrigeration.

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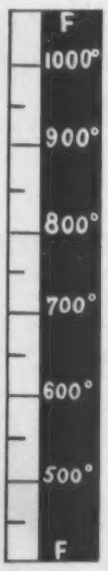
CECO HI-DEGREE COATING



Where other paints encounter high temperatures and burn off, CECO Hi-degree Coating adheres, providing a durable protection to steel and iron. Also, it retains its good appearance.

Leading oil and gas companies use it to protect hot metal surfaces. You, too, could use it to advantage. Try some and find out.

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The CECO line includes effective, protective and decorative paints for every purpose. Write us about your needs.

Mason-Neilan Demonstration

power plant engineers and instrument men to bring themselves up to date on control. They can see, in a few minutes, what would otherwise require many miles of travel, and many days away from their plant. They can get first-hand information on the latest developments in temperature, pressure and flow control. Control valve compensators that prevent overcontrol, overheat protectors, drift compensators and frictionless duo-coil action are shown, all in operation.

The complete demonstration is under the supervision of a control engineer who discusses problems, answers questions, and gives ideas on cutting maintenance costs. The unit is offered as a free service, no matter where it goes.

The large number of requests for demonstrations that have been received guarantees the success of the adventure, and has definitely established the truck as a permanent part of Mason-Neilan merchandising plans. New York, Philadelphia, Pittsburgh, Toledo, Chicago, St. Louis, Tulsa, and Houston are some of the larger cities included on the itinerary.

Potentiometer Pyrometer

THE BRISTOL COMPANY

The Bristol Company, Waterbury, Connecticut, announces the Wide-Strip Pyrometer, which is available in single-record, multiple-record and recorder-controller types. This instrument, operating on the potentiometer principle of temperature measurement, has a built-in accuracy that commands attention it is said. This accuracy is made possible through a simple measuring, balancing, and recording mechanism.

A stainless steel lead screw, operated by an electrical motor under the direction of two galvanometer-controlled contacts, adjusts the slide-wire contact and recording-pen unit to maintain emf balance in the potentiometer system. This mechanism introduces an entirely new principle of operation into temperature measurement by means of the potentiometer method.

Design of the balancing mechanism is such that all mechanical backlash is taken up, making it possible to magnify scarcely perceptible deflections of the galvanometer pointer. No clearance is required between the pionter and the chopper arms. Deflections smaller than 1/1000 of an inch are easily measured.

The pen movement is always proportional to the size of the galvanometer deflection. This accounts for the quickness with which balance is restored and for the speed with which temperature changes are written on the chart.

The slide wire contact and recording pen are mounted on the same carriage. This feature simplifies mechanical construction of the instrument and eliminates errors due to backlash, lost motion, etc.

The carriage on which is mounted the slide wire contact and recording pen, runs on four wheels over a substantial two-rail track. Three-point contact with the rails insures positive motion. It is driven through engagement with a hardened steel pin by a stainless steel lead screw. The lead screw, mounted on permanently lubricated ball bearings, is driven by an induction-type motor. There are no friction clutches nor ratchet mechanisms used.

This pyrometer records on a 12¼-inch chart; is equipped with a 1¼-inch indicating scale that can be read easily at a distance; uses a heavy-duty galvanometer enclosed in a dust-proof case; has a duplex slide wire mounted in such a position that the slide-wire contact and pen are integrally mounted on the same carriage; is designed and constructed to withstand an unusual amount of neglect and misuse; is housed in a convertible case which is moisture, fume, and dust-proof, a case combining in a practical way genuine utility with balance and conservative beauty; is fully automatic in operation; is simple in construction; is easy to service in the field by the user.

Gate Valve

THE OHIO INJECTOR COMPANY

The Ohio Injector Company, Wadsworth, Ohio, announced development of a new design in all iron gate valves in sizes one half-inch to two inches, which

O.I.C. Fig. 266

is cataloged as "O.I.C. Fig. 266." The valve is designed for 200-pound working pressure, is solid wedge type, stationary stem, and is recommended for acid, alkali and ammonia service, or any service where a cast iron valve is required. This valve is equipped with a follower gland and can be packed under pressure.

Petroleum Technologist, a Chemical Engineer, proven producer of results, 21 years experience, last 10 years engaged in oil refinery equipment design, construction and sales for large manufacturing firm, seeks connection. Address Box 256, care The Refiner, 3301 Buffalo Drive, Houston, Tex.